Departmental Report No. 36.

REPORT

ON THE

ORGANIZATION AND MANAGEMENT

OF

SEVEN AGRICULTURAL SCHOOLS

IN

GERMANY, BELGIUM, AND ENGLAND,

MADE TO

HON. GEORGE B. LORING,
U. S. COMMISSIONER OF AGRICULTURE,

BY

A. S. WELCH, LL. D.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

To Hon. GEORGE B. LORING,
Commissioner of Agriculture:

SIR: The following report comprises the results of a personal inspection of foreign agricultural schools and stations, made, in compliance with your request, during my late visit to Europe. In fulfilling the commission with which I was intrusted I have sought to present an *inside* view of typical institutions in Germany, Belgium, and England, with a hope of furnishing valuable information to the friends and promoters of industrial education in America. For this purpose I have described, mainly as I witnessed them, the organization, officers, methods of instruction, the spirit, equipments, and the experimentation of seven different institutions in the countries I have mentioned.

I heartily acknowledge my indebtedness to my secretary, Charles A. Keffer, for very efficient help in preparing my report for the press.

Hoping that these sketches may serve, in some degree, to improve the *ideal* of industrial education in the United States, I am, dear sir, yours, very truly,

A. S. WELCH.

AMES, IOWA, *June* 16, 1884.

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REPORT

ON

AGRICULTURAL SCHOOLS IN EUROPE.

THE ROYAL AGRICULTURAL ACADEMY AT POPPELSDORF, NEAR BONN, PRUSSIA.

The Royal Agricultural Academy established at Poppelsdorf, in connection with the Bonn University, belongs to the first class of agricultural schools in the Prussian system. Though nominally attached to the University, which is located in Bonn, a mile distant, it is entirely distinct from that institution in its organization, funds, management, and purpose.

The objects it seeks to accomplish are—

1. To give complete instruction to students in the sciences on which the various arts and handicrafts of agriculture are based.

2. To give to students such a knowledge of the facilities, processes, and products of agriculture as may be learned by observation of the best methods.

3. To carry on extensive experiments in every department of agriculture for the purpose of improving its processes and enhancing the value of its products.

4. To make original investigation in the sciences which underlie agriculture, especially in their relation to its processes.

For the first of these objects the Academy has a faculty of learned men whose lectures are comprehensive and minute; for the second, a well-managed farm, gardens, domestic animals, and collections for demonstration; for the third, extensive experimental grounds and stables; and for the fourth, the numerous laboratories under the direction of scientific experts.

THE FACULTY.

This body is composed of the director and eighteen professors, each of whom has charge of a single agricultural science or art on which he gives lectures, conducts experiments, makes examinations, &c. There are other officers, such as recorder and his clerk, and each professor has one or more assistants. The director and professors constitute a council

which has oversight of the general interests of the Academy and the harmonious arrangement of its various operations.

The director is the general executive officer and president of the faculty. He has control of all the funds appropriated by the Prussian Government for the support of the institution, reports annually to the minister of agriculture, and is held responsible for all matters not special to the departments.

THE STUDENTS.

In his published statement the director declares that two classes of students may avail themselves of the advantages offered by the Agricultural Academy:

1. Those who desire to qualify themselves for the duties of landlords or the management of large landed estates.

2. Those who, while pursuing a course of studies at the University, wish along with this to gain a scientific preparation for any of the professions connected with agriculture.

In practice, however, any young man of the middle or of the higher classes who has graduated from the Realschule (German high school) or passed the studies of the first two years of a German Gymnasium, is admitted to either of the two courses in the Agricultural Academy. It is required that the applicant should send in his papers, showing that he has passed the examinations alluded to in one of the above institutions before his name can be enrolled as a member of the Academy.

No GOVERNMENT.

No personal control or influence is exercised over the student. His name is enrolled on presentation of the required papers by each professor to whom he applies as a member of the class, but no account is taken of his presence or absence thereafter, and if he leaves without ceremony no notice is taken of the fact. The only restriction of which I could learn is the regular term examinations and the impossibility of maintaining the rank in scholarship essential to a diploma without passing them. There are in attendance 85 students, 45 in agriculture proper and 40 in agricultural engineering.

THE TWO GENERAL COURSES OF INSTRUCTION.

The courses of instruction are divided into two general curricula, one of which comprises the various sciences and arts in agriculture proper, and the other the branches preparatory to agricultural engineering.

At the opening of the next academic year a separate course in land surveying, constituting one year's study only, will be added to the course in agricultural engineering, which thus augmented still requires an attendance of two years for the final examinations and diploma. The engineers will hereafter be required to have passed all but the highest class of a German Gymnasium.

NEW COURSE IN FARM ENGINEERING.

The modified course in agricultural engineering will embrace—

First year. A course in surveying and natural sciences.

Second year. Hydraulics, mechanics, engineering, drainage, improvement and cultivation of moors, regulation of rivers, road building, &c.

The two curricula already noted include the following sciences and practical arts, which are invariably taught by lectures:

I.—*Introduction to agricultural studies:*
- (1.) Encyclopedia of Agriculture.
- (2.) Agricultural methods.
- (3.) History and literature of agriculture.

II.—*Natural sciences:*
- (1.) Mineralogy and geology, with practice in the minerals.
- (2.) Economic botany and plant diseases.
- (3.) Zoology, with anatomy of the domestic animals.
- (4.) Physics, with experimental practice.
- (5.) Chemical manipulation.
- (6.) Physiology, with practice on plants and animals.
- (7.) Agricultural chemistry; analysis of plants and manures; analysis of fodder and fodder mixtures.

III.—*Geodesy:*
- (1.) Pure mathematics, analytical geometry, and higher analysis.
- (2.) Field measurement and leveling, with practice in the use of instruments.
- (3.) Practice in adjusting and measurement with instruments.
- (4.) Land measurement.
- (5.) Topographical exercises in land triangulation.
- (6.) Practice with the aneroyd and tachymeter.
- (7.) Geometrical and topographical drawing.

IV.—*Technology:*
- (1.) Encyclopedia of Technology.
- (2.) Meadow making, drainage, drain irrigation.
- (3.) The study of ground for highways and water-flows; management of running water.
- (5.) Mechanics, specially of agricultural implements.
- (6.) Geometry as applied to field measurement.
- (7.) Descriptive geometry.
- (8.) Highways, water management, and street making.
- (9.) Practice in constructive drawing.
- (10.) Agricultural economy, technology.

V.—*Sciences of public economy and law:*
- (1.) National economy.
- (2.) Political economy.
- (3.) Laws relating to land.

VI.—*Agricultural arts under the different departments:*
- (1.) Field and plant culture.
  - *a.* Climate and soil, manuring, soil preparation, agricultural implements and machines.
  - *b.* Special plant culture.
  - *c.* Forage plant culture.
- (2.) Horticulture.
  - *a.* Wine culture.
  - *b.* Fruit culture.
  - *c.* Raising of vegetables.
  - *d.* Beautifying the land.

VI.—*Agricultural arts under the different departments*—Continued.

(3.) Forestry.

a. Tree culture and forest protection.

b. Profit of forestry, forest management.

(4.) Art of breeding.

a. General principles of breeding.

b. Special breeding, breeding of the horse, breeding for beef and milk, sheep breeding, breeding of small animals, bee breeding.

c. Health of house animals.

d. Shoeing and animal obstetrics; diseases of the house animals (acute and chronic).

(5.) Laws of business.

a. System of accounts and balancing.

b. Farm accounts.

c. Records of property.

(6.) The relation of the industrial sciences to agriculture.

The extensive facilities for illustration are embraced in the following list:

1. The experimental ground.
2. The economic botanical garden.
3. The garden for illustration of fruit and vegetable culture.
4. The chemical experimental station.
5. The physical and chemical analytical laboratories.
6. Laboratory of plant physiology.
7. Laboratory of animal physiology.
8. Laboratory of field experimentation.
9. Hall of machines for trial. Implements and machines, with steam engines.
10. Mineralogical, botanical, and zoological collections belonging to the Royal University.
11. Forest collection, wood specimens.
12. Models for instruction in architecture.
13. Collections for instruction in anatomy.
14. Agricultural collections.
15. Technological collections.
16. Models of agricultural tools and machines.
17. A special library of the industrial sciences and arts, 6,000 volumes.
18. Technical libraries belonging to each department.

I shall give detailed accounts of many of the above collections in subsequent pages under "Methods and Facilities for Instruction."

COLLECTIONS.

The scientific collections belonging to the general equipment of the Bonn Agricultural Academy and kept in the different laboratories far surpass in extent and completeness those which are found at kindred institutions in the United States.

In the first place, the vast museums of Bonn University are all open to the students of agriculture at the Academy. Each of these contains, often in a separate building, collections made in a single department of natural history, which in many cases comprise all the known varieties yet discovered. The museums of zoology, ornithology, entymology, paleontology, anthropology, &c., are extensive and full, and some of the

buildings which they occupy stand near those occupied by the Academy.

Across the street from the central academy building is the botanical garden of the University, wherein are grown all the plants indigenous to the climate, while extensive conservatories hold, in the highest condition, the plants of other climates, especially the tropics.

But beside the University museums, large special collections have been made by the professors in the Agricultural Academy, each of whom is curator of his own scientific equipment.

COLLECTIONS FOR ILLUSTRATION IN THE DEPARTMENT OF PRACTICAL AGRICULTURE.

Some of the working collections made by Dr. Werner are exhaustive, embracing every variety yet found.

COLLECTION OF WOOLS.

For example, the collection of wools comprises every animal product used for fabrics, and represents every variety of the wool-bearing animals throughout the globe. It contains 10,000 specimens, each neatly tied, labeled, and kept in its own compartment under glass. I examined specially samples from Vermont, from Southern Africa, and from Asia.

COLLECTION OF WHEATS.

This collection is also complete, presenting samples of all the varieties raised in the different wheat-producing countries. It is specially rich in the German and the Russian wheats and the wheats from Southern Europe. The entire list shows 600 kinds.

The various specimens in the wheat collection are, as in all other similar ones, preserved in glass tubes 6 or 7 inches long and 1½ inches in diameter, which close with a round top and are left open at the bottom for the reception of the cork. The tube is completely filled, neatly labeled near the base, and stands in the case on its corked end. For the reason that this tube presents no obstacle to the eye when the specimen is examined it is certainly superior to the vial used in many similar collections which I have seen.

COLLECTIONS OF OTHER GRAINS.

Large illustrative collections also of the varieties of rye, oats, barley, maize, &c., have been made and put up in the same manner. Some of the samples are surprisingly excellent in size and plumpness.

The above grains, including the wheats, were nearly all produced from experiments conducted in the agricultural department, the seed having first been obtained from many foreign countries where they are grown. Rye and oats, 150 varieties each; barley, 120.

IMPROVED POTATOES.

Six hundred sorts of potatoes, including the whole list of improved varieties yet produced, have been tested here and sample parcels of

each, selected from the crop, are labeled and preserved. The American, the English, and the German varieties are most numerous and make by far the best showing.

GRASSES.

To the above must be added the preserved specimens of all the cultivated grasses which grow anywhere on the grass-producing belt. Also samples of all plants used as fodders (such as millets) are a prominent feature of this collection, which comprises 250 kinds.

MUSEUM OF SEEDS.

The beautiful collection of seeds, embracing the entire catalogue of food plants wherever cultivated, forms also a portion of the ample equipment for instruction in the department of practical agriculture.

This museum, complete as it is in extent and classification, would delight the eye of an expert. It is the work to which a student whose enthusiam in this line never falters has devoted his life. The room it occupies is perhaps 40 by 60 feet, and through its center and along its walls are arranged numerous glass cases filled with tubes of uniform size holding the seeds, which have been brought to the highest possible excellence by previous culture in the botanical garden.

A botanical garden cultivated solely for improving the seeds of the nutritious plants and the consequent gathering of a museum of the best seeds are features in the equipment of an agricultural school which, so far as I am informed, are wholly unknown to the national schools of the United States. Why should not these institutions help, by similar means, to improve the garden and the farm?

IMPLEMENTS AND FARM MACHINERY.

In the department of agricultural mechanics, which is an adjunct of the department of agriculture, Dr. Gieseler, the professor in charge, has gathered what may be termed a museum of tools, which illustrate the progress of improvement in agricultural implements from their earliest use up to the present time.

The various classes of articles are arranged in series, each of which if read aright is really a history of the advancement of civilization. For every series begins with a crude, primitive implement and by successive steps ends in a modern complicated one. The grain-gathering series, for example, commences with an awkward hand sickle and, representing by many samples the lapse of centuries, closes finally with the latest reaper and binder.

Perhaps the most interesting class is that which shows the lineage of the plow. The earliest ancestor in the line is a pointed stick with a clumsy handle; the second has its point hardened by fire; in the third the point is roughly shod with iron and the handles set in at a convenient angle. A few steps farther on we find a decided iron point, and

beyond, with numerous intermediate samples, we reach the old Roman plow which has many appendages that were seemingly useless. Finally traversing the whole exhibit, which contains 600 specimens, one finds a steel gang plow, which is evidently an American invention, at its close.

The value of such a collection in an institution like this cannot be overrated, since it verifies the immense superiority of modern facilities for farm management and illustrates the progress of a great fundamental industry.

Among the numerous agricultural machines in this exhibit I noticed two American mowers (Wood's and Lieberling's), one English mower (Bamlette's), and one German mower (Reuter's).

These and other new farm machines or implements sent to the Academy for trial are tested in the field, and if found to be valuable receive the written indorsement of the professor of agricultural mechanics.

THE VETERINARY COLLECTION.

A capacious room, whose walls were occupied with suitable cases, contains in grim array, the skeltons of all the domestic animals. Also full sets of papier-maché models showing the anatomy of the various equine organs. Also complete sets of surgical implements used in veterinary operations, and horseshoes (steel and iron) of every form, size, and weight.

In this room, likewise, though the reason did not appear, are cases which hold the whole catalogue of birds that are harmful to the farm or garden. Beside each female bird was its nest of eggs. Along with these cases of birds stood others filled with the mounted forms of animals which prey upon or otherwise injure the farmer's crops.

Here, furthermore, as illustrations in the study of bee culture, were preserved all the varieties of the honey-bee, together with their combs in various conditions and stages of growth. This collection is completed with a display of the insect enemies of the honey-bee, showing their different forms from the egg to the last metamorphosis. This collection, it need not be said, belongs to the department of entomology.

INSTRUMENTS AND APPARATUS FOR WORK.

A description that should do justice to the apparatus for work in the laboratories and elsewhere would far exceed the space allotted to my report on this institution. It must therefore suffice to show, in a general way. their excellence and completeness of supply, avoiding the somewhat detailed account given of the experiments and the scientific collections.

Among the abundant facilities in the agricultural department for scientific work and investigation I found in a room used for that purpose 100 surveyor's instruments, all of the latest construction, pro-

tected by glass cases and kept in excellent order. These are, of course, used for instruction and practice by the professor of farm engineering, Dr. Vogler.

In another apartment was a classified collection of woods, each specimen prepared so as to show a polished surface, and the whole seemingly large enough to embrace exhaustive samples from all the forests of the globe. These are brought into requisition for illustrating the lectures given by the forester, Forstmeister Dr. Sprengel.

BOTANICAL LABORATORY.

Among the facilities for work in the botanical laboratory, which occupies four spacious rooms, I noted a score of microscopes of the latest make for the use of students in the study of structural botany.

The herbarium corresponds in extent and systematic thoroughness with other collections already described. I noticed a large number of papier-maché models of tropical plants for illustration in lectures. Indeed, in the whole outfit of the botanical department nothing seems wanting that can help the professor in his original researches or enlighten the pupil in his studies. A visit to its ample chambers, its museum of seeds, the laboratory for plant analysis, the lecture room, the library, and private office, each abundantly supplied with facilities appropriate to its purpose, would gladen the eye of an American botanist and beget the hope that some time in the future the botanical department of our national colleges might be equipped with a similar liberality.

THE CHEMICAL LABORATORIES AND THEIR EQUIPMENT.

In company with Dr. Gieseler, to whom I am under obligation for many courtesies, I visited the spacious rooms of the chemical laboratories, and was introduced to the accomplished professor of chemistry, Dr. U. Kreusler.

It must be kept in mind that these laboratories are limited to two special purposes, namely: (1) To give the students instruction and practice in the analysis of foods, fodder, plants, manures, and soils, and (2) to enable the chemist to make original researches to determine the constituents of the same substances. In other words, they are in no respect general laboratories, but are specially devoted to instruction or research in agriculture.

There are two apartments or sets of rooms, the one devoted to instruction and practice, the other to original research. The first comprises five large rooms, viz:

(1) A. laboratory for practice in the analysis of plants, 30 by 40 feet. Beside other abundant apparatus this room contains five large balances for the use of students.

(2.) A room for the advanced class where 30 students have convenient tables with water, gas, and all other appurtenances. Here are two fine large balances.

(3.) A chemical library of 400 or 500 volumes.
(4.) A lecture room with 100 seats.
(5.) An office for the professor in charge.

The laboratory for scientific researches occupies five rooms of nearly the same dimensions as those of the laboratory of instruction. They consist of, first, the room for analyses, 40 by 60 feet, which is furnished with abundant apparatus for all those minute operations by which the elements of organic compounds are determined.

As a specimen of the excellence and completeness of his equipment for chemical investigation, Dr. Kreusler pointed out among his balances a large pair manufactured by H. Shickert, Dresden, whose adjustment is so delicate as to detect the exact weights of substances under experiment in a range from 5 kilograms to .00002 of a gram. This is regarded as the best chemical balance made in Germany or elsewhere.

In this room an experiment was in progress under Dr. Kreusler to determine (quantitively) what elements of the atmosphere are taken up by the plant in the progress of growth. This experiment is evidently extremely difficult, necessitating the confinement of the air in which the plant is grown, and after a definite period finding by operations so nice that the slightest error would vitiate them what atmospheric atoms have been consumed.

The second room attached to this laboratory was occupied with the larger apparatus and machinery, prominent among which is an electrical machine propelled by water, equivalent to 2½ horse-power. This piece of apparatus belongs, however, to the department of physics.

A third room contained another library on higher chemistry, its processes and achievements. It is a marked proof of the extent to which the German agricultural schools have divided and specialized their lines of work that each professor is furnished with a working library that treats of the subjects within his specialty. Every department here has its library, and a moderate yearly appropriation enables the professor to make such additions as will keep it abreast with the advancement of the science it embodies. I heartily commend this feature in the organization of the Bonn Agricultural Academy to the trustees of the national schools in the different States of the American Union.

A fourth room is fitted up for the laboratory of Dr. Kreusler, and a fifth is his private room, wherein are kept the records of all operations and experiments conducted in the laboratory, with their outcome, whether of success or failure.

EXPERIMENTATION.

Dr. Dreisch, who has the experimental grounds in charge, conducts the experiments, and keeps an accurate record of all the steps from the sowing of the seed to the final gathering and stowing of the crop.

THE EXPERIMENTAL GROUNDS.

The experimental grounds consist of 18 morgans (16 acres) of Rhine bottom land, lying in a square. Dr. Dreisch informs me that the land has a natural drainage through a layer of gravel 2 feet beneath the surface. The soil is a rich red loam, with plenty of lime, and has a depth of from 10 to 12 inches. The entire square is divided by a broad walk, or road, running through the center, and the different crops under trial occupy, with their varieties, long narrow strips of land, whose bases rest upon the walk.

EXPERIMENTS IN MANURES.

The series of experiments to determine the relative values of stable manure and the different commercial fertilizers is very systematic and minute.

The first step, which is obviously an important one, is to make the soil on which the experiments are to be conducted perfectly uniform in fertility throughout. This is accomplished in the following manner: A crop of green mustard is raised on the land for several successive years in the fall after the regular crop has been gathered. Any unevenness in the crop at the time of cutting indicates precisely a corresponding lack of uniformity in the productive quality of the soil. Each crop of mustard is cut green, taken off, and composted, and the compost is brought back the next year, and, after the regular crop has been gathered, is spread upon the same surface in such a manner as to correct all inequalities of fertility previously shown.

When a perfect evenness in the productive quality of a morgan has been thus secured, it is prepared for an experiment to determine the comparative value of different commercial fertilizers by plowing and harrowing repeatedly until it is reduced to the finest tilth. The morgan is then divided by parallel lines into as many different parts as there are fertilizers to be tested, and these parts are numbered for convenient record, thus:

FIG. 1.

6		1
7		2
8		3
9		4
10		5

Each fertilizer is then mixed thoroughly with compost and spread evenly on the surface of one of the divisions. The same weight of compost is used with each mixture, and the commercial fertilizers in the

different compounds have the same market value. Thus, let the number 50 stand for the quantity of compost in every mixture, and the letters A, B, C, D, &c., for the different fertilizers. The compounds are then as follows:

50 + A, plat 1.
50 + B, plat 2.
50 + C, plat 3.
50 + D, plat 4.
50 + E, plat 5.
50 + F, plat 6.
50 + G, plat 7.
50 + H, plat 8.
50 + I, plat 9.
50 + K, plat 10.

In this list of compounds K represents cow manure, which serves as a standard of comparison for all the others.

After these different fertilizers as composted have been spread evenly, each on its own plat, as shown in Fig. 1, the entire morgan is thoroughly harrowed, and a single hardy variety of winter wheat is sown in drills over its entire surface. The hand drill used for the sowing has been carefully cleaned and so adjusted as to drop the seeds evenly in the drills. The whole morgan then receives another harrowing, the lines dividing the plats being preserved by short stakes driven well into the ground.

One might suppose that the experiment in fertilizers thus begun would need no further attention until the crop should be ready for harvesting. But the German experimenter never loses sight of the crop which is under experiment. The condition of the wheat plants is noted frequently from the appearance of the plumule up to the ripening of the wheat. The wheat receives at least three hoeings during the season. An account is also taken daily of the weather as to changes of temperature and moisture. All the facts thus observed are entered, each under its own date, in the "Record of Experiments," wherein an account of every experiment is carefully and systematically kept.

When the crop is ready for harvesting it is cut with a sickle and the wheat on each plat is gathered and bound in sheaves, stacked by itself and labeled. On the lines dividing the plats, where two kinds of manures come in contact and mix slightly, a narrow strip of wheat is left standing. As soon as the shocks are in proper condition they are transferred to the same mow, but kept separate by means of linen cloths, which effectually prevent mixing. Afterwards, as soon as may be, they are thrashed with a small one-horse machine, which, after finishing the contents of one plat, is thoroughly cleaned before beginning another. The grain from each plat is put into bags, properly labeled, and afterwards weighed, and the comparative weight determines the comparative value of the fertilizer which stimulated its growth.

It is obvious that the above experiment may be made more minute by increasing the number of plats in the morgan, and using a greater num-

ber of artificial manures, or by varying their quantity in the different plats.

It will be seen at once that the above experiment answers two important questions: First, what is the value of a given commercial fertilizer in wheat raising as compared with other commercial fertilizers? and, second, what is its value in comparison with cow manure?

EXTENT OF EXPERIMENTS IN CROPS.

The experiments in crops this year include wheat, rye, oats, barley, potatoes, beets, and the seeds of all the nutritious plants that grow in this latitude. The varieties of wheat now under trial on the experimental grounds occupy two or three morgans of land and are looking well. The Kaiser wheat, a German variety, shows the most promising growth. The plants stand (November 10) 4 inches high in drills 7 inches apart. The other kinds are also healthy and strong.

Dr. Werner, professor of agriculture, conducts another series of experiments on the farm for demonstration, which is entirely separate from the experimental grounds under charge of Dr. Dreisch.

DR. WERNER'S EXPERIMENTS.

Dr. Werner's experiments in winter wheat number six hundred varieties, which include all that are now cultivated. Among them is a long list of American sorts. Dr. Werner has lately given to the public the results of his wheat experiments in a large volume on "The kinds of wheat best adapted to German soils," which is regarded as the highest authority on that subject.

His work in this line embraces also extensive experimentation on the improved potatoes, and the list which he put under trial embraces all the valuable varieties yet produced. I noticed that the larger number in his catalogue were American, English, and German potatoes, the whole list containing six hundred and fifty sorts. In his experiments on the improved potatoes Dr. Werner employed the same methods which I have given in detail in describing Dr. Dreisch's experiment on the winter wheats. The same care is used in selecting ground that is uniform in the depth, moisture, and qualities of its soil. Great pains are taken to bring the soil to a previous even fertility. The different kinds of seed are so selected as to secure uniformity in size and soundness. The planting of different varieties is at the same depth, and the same number of stalks are left in the hills; the cultivation is regular and thorough. Weather, appearance, rate of growth, degree of health, harmful insects, periods of ripening, &c., are all frequently noted and entered on the record, wherein a page is assigned to each variety. When the decay of the stalk shows that a variety is ripe, the digging is done so carefully that no potato is bruised or cut. The yield is sorted, bagged, labeled, weighed, and stored, and subsequently

the weight, size, and quality are taken into account in answering the question, *What are the best sorts of potatoes to raise for the table?*

EXPERIMENT IN WHEATS.

All the successive operations in this experiment are conducted with minutest care. Every circumstance that can by any possibility inter fere with certainty in the result is carefully eliminated. The first requisite is to bring the soil chosen for the purpose to an unvarying fertility throughout. This uniformity of productiveness is gained (as I have already said) by applying the compost of green crops, and tested at last by the evenness of their growth.

The ground selected for the experiment (one or more acres) may be kept two or three years in a course of preparation, and grain of any kind may mean time be raised upon it; but immediately after the grain is harvested each year a crop of green mustard is sown and allowed to grow until late in the autumn, when it is gathered, mixed with soil, and left in the compost heap through the winter and the following summer until the next grain crop is taken off, when it is returned to the soil, being carefully spread in such a manner as to correct any irregularities of productive capacity shown in its previous growth. In other words, the compost of green mustard is spread thickest on spots where the crop of the last autumn was the lightest and thinnest where it was heaviest. Finally, when, in this way, a green crop is reached, which stands perfectly level and is of uniform weight on equal divisions of surface, the ground is ready for an experiment or a series of experiments on the comparative value of different wheats.

The ground is now prepared for sowing by plowing and afterward harrowing and rolling several times in succession. When reduced by this means to the finest tilth possible the entire surface is divided into as many equal parts as there are varieties of wheat to be tested. Supposing that ten varieties have been selected for experiment, we have the divisions shown in Fig. 2:

FIG 2.

No. 1.	**No. 6.**
No. 2.	**No. 7.**
No. 3.	**No. 8.**
No. 4.	**No. 9.**
No. 5.	**No. 10.**

The plats so marked out are numbered and entered in the "Record of Experiments," together with the name of the wheat under trial. It will be seen that the division leaves a narrow strip of unoccupied ground

between the varieties. The seed in each variety has been obtained by sifting out the smaller grains through a sieve and thus retaining only the larger and plumper kernels. Each kind of seed is sown on its plat in drills six or eight inches apart with a seeder, which is carefully cleaned before it is used on the next plat. The utmost precaution is taken against mixing varieties.

No sooner do the young plants appear than a system of observation begins which is minute and exhaustive in the last degree. A double page on the record is assigned to each variety, and every fact which affects the growth of the stand, as well as its condition and appearance at different stages, is noted and entered in such a manner as to give clearly within a limited space a complete consecutive history of the experiment from its beginning to its close. Among the items gathered and recorded daily are the weather, its changes of temperature and moisture, the size of stock and leaf, color, health or disease, the presence or absence of insects or fungus growths, the effect of cultivation, and the time of sowing and ripening.

When any one of the varieties occupying a plat is found to be properly ripened it is cut with a sickle (to avoid waste by shelling), bound in sheaves, shocked, and labeled. Then, when in the right condition, it is removed to the mow and there kept from the possibility of mixing with other varieties by means of cloths. The thrashing takes place as early thereafter as may be, a small one-horse machine being used, which is scrupulously cleaned after a single kind has been through. The grain of each variety is gathered from the machine in bags, labeled, and stored away.

In the above experiment it is evident without saying an answer is sought to the question, *What wheats are most profitable for German soils?*

The experiment is completed with three final steps:

1. The bags containing the different varieties are compared as to their gross weight.

2. The smaller grains are then sifted out of each variety, leaving only the larger and more perfect berries, and these are again compared, *in weight*, with the grains of the other varieties similarly separated.

3. The quality of the flour made from the different wheats is tested by comparison in the actual loaf.

It should be added that tubes containing specimens of each variety so tested are labeled and preserved in the museum.

DR. WERNER'S EXPERIMENTS IN CROSSING BREEDS OF CATTLE.

An interesting series of experiments is now in progress under the direction of Dr. Werner to improve the German milking stock. It is the purpose in these experiments to correct the defects and increase the yield of the various milk-breeds in Germany by judicious crossing. The material in this country for such an undertaking is far better than

in America. Our native cow, herself the product of innumerable hap-hazard crosses, does not furnish a proper basis for the beginning of such an experiment, and. though the cross with blooded stock is undoubtedly a great improvement. it is due to the superior prepotence of the pure-bred bull, and neither accuracy of result nor persistence of type can be relied on. In the various agricultural districts of Germany and Switzerland there are many milk races bred with more or less care and each having its peculiar merits and defects. The cows from these breeds will, therefore, supply for a trial in crossing such fixed peculiarities that the characteristics of the resulting calf may be definitely fore-seen.

I found standing in the stable attached to Dr. Werner's residence twenty-four cows representing several of the above races. Of these I may mention two Swiss Mountain cows which were in calf by the Short-horn bull. The Swiss Mountain milker is pre-eminently the peasant cow of South Germany and Switzerland. She is emphatically a beast "of all work," combining the qualities of a milker, a draft, and a beef animal. She supplies the peasant family with food, plows their acre either singly or paired, and when too old for further use is fattened for the market. Probably she is better fitted for these three purposes than any other race in the world.

In form she is what might be called ungainly, but her peculiarities are transmitted with remarkable uniformity. The head and neck are large and clumsy. the chest is broad and deep, the hind quarter comparatively light, and the rump set up so high as to approach deformity. In consequence, the fore legs are short in proportion to the length of the hind legs. The entire figure suggests the probability that it was developed by habitual climbing in a mountainous country. Though the form of the cow is the reverse of that claimed as most suitable for the model milker, she carries a broad, good-sized udder, and is said to be an excellent milker.

In the adjacent stall stood three Switzers, a race remarkably similar to the Jerseys in all characteristics, except size. The horns, the delicate blood-like face, the rings around the eyes and muzzle, the color, slender limbs and broad udder, and indeed the whole figure are wonderfully Jersey-like. But these cows weigh, I judge. from 1,200 to 1,300 pounds. So far as the milk points can decide the question, the Switzer is superior to all other milk breeds on the continent. She is bred with great care in the vicinity of Berne, Switzerland, and is sometimes called the Bernese cow. Animals of this breed imported to America would make a valuable addition to our milking stock.

There were several specimens of the Simmenthaler, another Swiss milking breed; animals of good size; color, red and white; somewhat coarser, but showing fair milking qualities.

Dr. Werner pointed out further a few samples of the Glan and Westerwald races, both natives of the Rhine Province. They are large and coarse, but showed a fair development of udder and milk veins.

In addition to the above were eight or ten Hollander cows, perfectly black in color and heavy and square in form, evidently bred for beef as well as milk.

Finally, the collection is complected with a half a dozen Friezeland milkers, a race well known as closely akin to the Holsteins, but more finely and carefully bred.

The male used for crossing with these cows is a Durham bull, called here a milk Short-horn. This bull is a Duke of Airdrie, and his dam was a pure Princess cow. Dr. Werner holds the opinion that the family of Short-horns whose milking qualities were preserved and improved by Bates furnish the best milkers in the world, and that consequently the males crossed with the females of the German milk breeds will produce animals of increased capacity as milkers. He does not explain how he proposes to make the characteristics of the milkers resulting from the various crosses fixed and permanent in the generations following.

Dr. Werner pointed out with some pride the points in this milk Short-horn bull which indicate his special excellence for the purpose in hand. And indeed the slender head and throat, the chest of moderate width, but unusual depth, the broad level hind-quarter, and the general symmetry of this fine animal, seemed to justify the doctor's estimate of his value.

This experiment for improving the native milkers was commenced last year, and there are now, as the first results, fifteen calves divided as follows: Ten from Hollander cows, one Switzer, three Glans, one Westerwalder. These calves, which were in fair condition, showed in a marked degree the characteristics of their dams, which seemed to indicate a lack of comparative prepotence in the Short-horn sire. It is, however, too early to predict their final outcome in form and quality.

In the same stable are also ten or twelve two-year-old heifers which are the outcome of an experiment in crossing to produce stock having superior beef qualities. In this experiment, which was completed two years ago, a Booth Short-horn bull of decided prepotence and marked characteristics was crossed with the Hollander and Westerwalder cows, and the results, as shown in these heifers, are full of promise.

EXPERIMENTS IN SHEEP.

A series of experiments is also in progress to improve the races of native German sheep. In these experiments two results are sought: (1) To enhance in certain breeds the weight and fineness of the fleece; (2) to increase the mutton and improve its quality.

Southdown, Oxfordshire, and Lincoln rams have been imported from England for the first purpose, and Spanish Merino and Rambouillet rams from France and Spain for the second.

The whole collection includes 4 Southdown rams, 6 Lincoln rams, 5 Oxfordshire rams, 15 Spanish Merino (part ewes), 5 Eifeler ewes, native German mountain sheep, 4 Heidschnucken ewes, black sheep; 4 Texel

ewes, Holland breed; 4 Ostfriesen ewes, native; 2 Marsch ewes, native.

The foreign bucks are striking specimens of individual excellence in form, size, and quality of fleece. A sample of wool from the Rambouillet is remarkably soft, long, and fine.

The first lambs resulting from this cross of foreign bucks with native ewes came in last spring and look thrifty and promising.

EXPERIMENTS IN FEEDING FOR MILK.

Protracted experimentation has been carried on with minute care by the professor of agriculture to determine the comparative values of various food-mixtures for the production of milk. The food-mixture while being fed has its ingredients submitted to chemical analyses, so that a double series of results may be made, if possible, to verify each other. In this way theory and practice are kept abreast in every inquiry.

The results of these food trials, which where lasting and thorough, have been published by Dr. Werner in a volume entitled Futterban, Plants for Feeding—a work which is of high authority in Germany. Another work on Die Kuh Milch—the milch cow—describes also a series of experiments on feeding, and handling milk.

After long trial on compounds for milk making, the professor offers the following mixture of fodders as the best he has found:

Winter feeding for one day, per 1,000 *kilograms* (2,200 *pounds*) *living weight.*

[Assimilated substances. Chemical composition.]

Name of fodder.	Weight.		Dried.		Albumen.		Starch, sugar, &c.		Fat.	
	Kgs.	*Pounds*	*Kgs.*	*Pounds*	*Kgs.*	*Pounds*	*Kgs.*	*Pounds.*	*Kgs.*	*Pounds.*
Mangels	85	179.2	10.2	22.44	0.45	0.99	9	19.80	0.09	0.198
Hay	6.5	13.3	5.5	12.10	0.55	1.20	2.6	5.72	0.10	0.220
Malt refuse	6.5	13.3	5.9	12.98	0.85	1.87	3.3	7.20	0.10	0.220
Oil cake	2.2	4.84	1.9	4.18	0.55	1.21	0.6	1.32	0.20	0.440
Chaff (oat and rye)	4.4	9.68	3.5	7.70	0.10	0.22	1.5	3.30	0.01	0.022

HORSES AND PIGS.

The stock of hogs is limited to five, namely: One large Yorkshire boar, of moderate merit, and four sows of the same breed. Of horses there are only three Belgian, which are kept simply for farm work.

FARM FOR DEMONSTRATION.

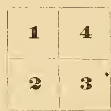
This farm, which is used by the professor of agriculture as an apparatus to illustrate the cultivation, growth, and special profit of the various crops, comprises 28 hectares (60 acres) of level land. The soil is a rich loam, containing plenty of chalk. Since previous manual practice and experience in farm operations are conditions of admission to the Academy the students do not labor on the farm for demonstration

or elsewhere. It is managed by Dr. Werner and is worked by experienced farm hands, who are paid 2 marks (50 cents) a day for their services. To the college classes this farm gives facilities for observing the results of scientific management, and to the professor such instances as he needs in his lectures on the various agricultural products.

ROTATION.

The farm is cultivated according to a method known as the Norfolk system. Its entire area is divided into four equal parts for regular rotation of crops, as follows:

FIG. 3.



No. 1 was occupied this year with mangel-wurzels; No. 2 with oats; No. 3 with red clover and Italian rye grass; No. 4 with two varieties of wheat, viz., Sherriff's square head and the Imperial wheat. Next season No. 1 will be sown with wheat (No. 4); No. 2 with mangels (No. 1); No. 3 with oats (No. 2), and No. 4 with red clover and Italian rye grass. In this way the rotation will be completed in four years.

The average crops are as follows:

[One hectare equal to 2½ acres.]

	Kilograms.	Tons per hectare.	Tons per acre.
Average crop of mangels	100, 000	110	44
Maximum crop of mangels	110, 000	121	48. 4
Average crop of wheat	2, 500	2. 75	1. 1
Maximum crop of wheat	3, 000	3. 3	1. 32
Average crop of oats	3, 000	3. 3	1. 32
Maximum crop of oats	5, 000	5. 5	2. 2
Red clover and rye grass	10, 000	11	4. 4

Amounts used in seeding.—Wheat, 100 kilograms, equal to 220 pounds per hectare, or 88 pounds per acre; distance of the drill rows, 30 centimeters, equal to 12 inches; cultivated twice with the horse hoe. Oats, 100 kilograms, equal to 220 pounds per hectare, or 88 pounds per acre; distance of the drill rows, 20 centimeters, equal to 8 inches; not cultivated with the horse hoe, but sown with 32 kilometers, equal to 70.4 pounds of red clover and Italian rye grass in equal weights each.

MANURING.

In the above system of rotation each division is manured once in four years. A mixture of green and liquid stable manure is applied yearly at the rate of 160,000 kilograms, equal to 352 tons, per hectare, or 70.4 tons per acre, to that section which is to be sown to mangels. One-half

of this quantity (80,000 kilograms per hectare) is spread on the ground and plowed under 26 centimeters (10.4 inches) deep, immediately after the preceding wheat crop has been harvested. The other half is applied to the same ground the following spring and covered lightly with the plow. The ground is then harrowed and sown in drills, and the mangels being gross feeders and requiring much cultivation, the fertilized soil is gradually prepared for the other crops which follow in the above-named rotation.

Does the farm for demonstration pay?

Professor Werner informs me that a fixed sum is appropriated yearly by the Prussian Government to the support of the farm, but that the proceeds from the sale of its products must go back to the treasury. He showed by reference to his ledger, in which I found an itemized balanced account kept with every crop, that the earnings of the farm had exceeded its expenses every year. It must not be forgotten, however, that the farm does not bear the burden of student labor, but is worked by regular laborers at 50 cents a day. It was gratifying to learn that the superintendent is permitted to invest the excess of its earnings over expenditures in needed improvements, and it was consoling, I confess, to hear him grumble, like an American, at the magnitude of his needs compared with the smallness of his means.

ECONOMIC BOTANICAL GARDEN.

One of the most valuable means of instruction connected with this Agricultural Academy, is the botanical garden, under the charge of Dr. Koernicke, professor of botany. It is an inclosure which lies immediately behind the main building and comprises about two morgans of land (1¾ acres), laid out in long beds, which are separated by narrow walks and kept scrupulously clean.

In this garden are cultivated all the varieties of nutritious plants that mature in open air in this climate. The treatment and cultivation of each plant is carefully adapted to its habits, so that its seed may be obtained in the highest possible perfection. When ripe the seed is gathered, cleaned, and sifted. Then a portion is put into vials, labeled, and placed in the museum of seeds of economic plants.

Special efforts are made in this garden to improve the garden vegetables and bring their seeds to the highest excellence. The consequence is that the collection of seeds in the museum of economic botany, most of which were produced here, is unsurpassed by any similar collection in the world. The unusual perfection of all the different varieties makes the display a remarkable one.

Striking samples taken from this collection, together with the fruits produced in the botanic garden, were exhibited by Dr. Kœrnicke at the Exposition in Vienna, held in 1873.

It is obvious that the economic botanical garden may be regarded as among the most important means of illustration. It belongs to the general equipment, to be used like any other apparatus, and as such furnishes to the students opportunity for observing the modes of propagation, growth, culture, and preservation of the food-plants. It would be well for kindred institutions in America if such helps in teaching could be added to their equipments.

I may further say that a systematic record is kept of all the operations and results in the botanical garden and of the seed collections in the museum.

SPECIMEN LECTURES.

THE FRIESLAND COW.

A lecture given by Dr. Werner on the Friesland cow will serve to indicate both the methods of instruction given here and its extreme thoroughness. It was delivered in a stable instead of the open air because of a pouring rain. The specimen used for illustration was a Friesland cow well stricken with years, and decidedly defective in form and quality. It seems she had been chosen for the purpose of showing the defects which are possible in the breed.

A class of young men, fifteen in number, stood around the animal with open note-books, giving the closest attention.

The professor began by describing minutely the form and characteristics of a perfect milch cow. He represented the ideal milker as a machine for transforming the coarser foods into the largest possible amount of good butter and cheese. He said that the animal could not answer this purpose completely unless she possessed, in high degree, certain characteristics of form and quality. First, none of the parts that go to her general make-up should be incumbered with surperfluous weight. Every organ must have neither more nor less than its due proportion of size and compactness. Any excess in the size of a part involves a corresponding waste of food used up in supporting it. A broad chest or a heavy brisket in a milch cow absorbs a portion of the material which would otherwise go to milk. The digestive apparatus, the stomach, the secretion apparatus, milk veins, and udder must all have not only the highest, healthy activity, but they must be developed in certain proportions to each other. The office of the general frame is to support the milk organs, and both in size and shape it should be precisely adapted to its purpose. Inasmuch as the hind quarter sustains the principal milk organs, it should be correspondingly large. The loins must, therefore, be broad, the hips wide apart, the line from hip to rump long, the flanks well down, and the hind legs wide apart. All this will make the hind quarter proportionately more capacious than the chest, which needs only room enough for a good-sized heart and stomach. This will give the model milker a shape which is slightly conical, and which is due to the greater development of the posterior parts.

The professor further insisted that every organ, whether special or general, should be fitted in size and strength to its particular design in the economy of the animal. The milch cow is not a roadster; her legs, therefore, may be delicate and short to serve the purpose of only moderate locomotion. She is not a fighter, and, therefore, slight horns and a slender neck are most becoming to her. She is not (or should not be) a draught animal, and consequently her muscular system ought not to be developed to a capacity greater than is sufficient to support the digestive apparatus and special milk organs.

But all these facts, continued the lecturer, may be stated with mathematical exactness. The size of the milch cow being given (which is a matter of great moment), all her points would, if she were a perfect milker, be developed in a definite proportion to each other that could be measured and set down in exact figures. The length of head and neck and body, the depth and girth of chest, the breadth of loin, depth of flank, and length of limbs, would stand in an unvarying ratio to each other. Of course there are other indispensable requirements which cannot be submitted to measurement; among these are a soft and flexible skin, of moderate thickness, thick and elastic hair, and delicate offal throughout. But to these must be added, as the crowning characteristics, a sound constitution, vigorous health, and large and active milk organs.

"Now," continued the lecturer, "let us see how the Friesland breed comes up to the standard which I have given you. Really, no breed has yet produced that ideal animal, the perfect milch cow. The Jersey, otherwise excellent, is too small; the Ayrshire inclines to fat as she grows old, and refuses to breed; the Short-horn, which has, of all the bovine breeds, the finest fiber and most flexible organization, was originally a profuse milker, but she has, in most families, had her milk organs reduced, if not dwarfed, by subsequent breeding for beef.

"The Frieseland cow attains good size, and has an abundant flow, but her bone is somewhat coarse, and she carries generally too much of fat for a model milker, faults which might perhaps be remedied by judicious crossing with milking families of the Short-horns.

"The cow you see before you, young gentlemen, is full of defects, even as a specimen of the Friesland breed. In size, to be sure, she is all that could be desired (here the professor made rapid measurements); her top line, indeed, from rump to shoulder, is precisely equal to the line from shoulder to muzzle, and the distance between the eyes is half the length of the face, which are the right proportions. The muzzle, the space between the horns, the throat, and the base of the neck, show just the normal shape and size; but the chest lacks sufficient depth, and its girth is too small by 3 inches to hold a healthily-developed heart and stomach. The hind quarter comes nearer to filling the bill; the loins have the proper breadth, and the hips are just the right distance apart; but the line from hip to rump is 2 inches short, and the

tail is set on 4 inches too far in, which hurts the symmetry of the whole hind quarter.

"As to the twist, we find it seriously defective; the thighs have the requisite flatness, but they are so near together as not to afford sufficient room for the udder, which is consequently too narrow at the base and too long, thus bringing the teats nearly into contact with each other.

"A model udder is broad in proportion to its length, thus filling out an ample twist; the teats stand well apart and are of the right size for the hand of the milker."

The lecturer proceeded in this manner until every point and part of the animal was thoroughly analyzed; then raising his hat he thanked the young men for their attention, and we passed out, leaving them to follow.

LECTURE BY DR. GEISELER ON THE MOWING MACHINE.

The exhaustive minuteness with which every subject is taught was illustrated in a lecture given by Dr. Geiseler, professor of agricultural mechanics, on the structure and management of the mowing machine. The class consisted of fifteen young men, who occupied desks and made rapid entries in their note-books as the lecturer proceeded.

The doctor began by describing separately the properties of cast iron, wrought iron, and steel, and showing the different purpose which each served in the make-up of the machine. A model machine was before him, and he illustrated every statement by exhibiting the part referred to and by rapid sketching on the blackboard. Those parts in which strength alone is needed and bulk is not objectionable are made of cast iron, but for such parts as need strength and elasticity combined wrought iron is used, while the pieces which are so located as to receive the greatest strain and friction—pieces, in short, which do the most work, must combine the greatest strength, hardness, and elasticity in the smallest compass; these must be made of steel. Here the lecturer, taking the machine rapidly apart, showed each steel piece separately, explained its purpose, gave the reasons for its shape, pointed out its possible defects, and suggested improvements; named the accidents to which it would be liable and the remedies therefor.

He dealt with emphasis on the more important parts, especially the sickle, of which he exhibited a number of samples.

He went on to explain how the sickle is made, its best shape and length, where defective, how kept in order, how abused, how clogging can be avoided, how the rivets should be put in, how replaced when broken, and he finally closed by showing the comparative advantages and defects of the different machines, criticising freely the samples he had from several well-known American manufacturers.

The following skeleton of a lecture on wheat culture by Dr. Werner, before a class of twenty students will suffice to show his method of instruction in the various field crops.

Rapidly writing the scientific names of each plant or insect as he mentioned it, he dwelt first on the seed; the necessity that it should be sound and healthy; how obtained; the best varieties; what soils produce the best wheat; how prepared for sowing; the implements for sowing and cultivating, and their uses; the various weeds that infest wheat, with the habits of each, and the best means of extermination; the insect enemies of wheat; their various methods of propagation; diseases of wheat; the healthy varieties which are free from fungi.

ORIGINAL INVESTIGATION MADE AT THE BONN AGRICULTURAL ACADEMY.

It may be premised that original investigation in the line of industrial science or art is the highest work undertaken in an industrial institution. The extent to which the officers of this school have helped to enlarge the boundaries of practical knowledge may be inferred from the following condensed statement.

The results of original research made at the Bonn Agricultural Academy will include all the new knowledge gained from protracted experimentation in several lines, embracing the products of the farm and garden and the various domestic animals.

These include:

1. A series of experiments already mentioned, conducted by Professor Dr. Werner on the foods and forage plants for the most plentiful and economical production of milk. The experiments include also the breeding of the cow and the management of milk. The results are embodied in a volume published by Dr. Werner, entitled Kuh-Milch—milch cow.

2. Another series of experiments by Dr. Werner is published, with the results, in a book entitled Plants for Feeding.

3. The outcome of extensive experiments on 600 varieties of wheat by the same professor has been set forth in a book on The Best Wheats for German Soils.

4. The experiments in breeding, including (*a*) the crossing of the native cows of Northern Europe with the "beef" Short-horn, for securing native animals of better beef quality.

(*b*.) The experiments now in operation wherein the native and other milkers are crossed with a "milk" Short-horn bull, to improve the milk qualities of subsequent generations.

(*c*.) The crossing of the ewes of native breeds of sheep with the rams of the English, the French, and the Spanish breeds, for the purpose of improving the quantity and quality of the fleece and mutton.

5. The production, by Dr. Volger, professor of botany, of all the varieties of seeds from the nutritious plants, in a condition of special excellence, as shown in the museum of seeds, must also be reckoned among the contributions to knowledge made here.

6. Contributions made in the improvement of the various products by culture in the botanical garden.

7. The innumerable analyses made in the chemical laboratories by Professor Dr. Kreusler to verify the results reached in practical experiments on the farm or other grounds, as instanced in my account of Dr. Werner's trial of the food mixtures for the milk flow.

8. Minute and complete observations by Professor Kreusler on the growth of food plants, noting time, temperature, moisture, sunlight, state of soil, and all the minute circumstances that affect the vigor and growth of the plant.

One of the printed pamphlets in my possession, entitled Observations on the Growth of the Mais Pflange (Indian corn), by Dr. Kreusler, assisted by Drs. Prehn and Hornberger, contains three large charts; the first showing, at the close of each week, all surrounding conditions which affect growth; the second presenting the increase of dry weight in certain periods of growth, together with the completion of leaf surface and final maturity; the third exhibiting the periodical growth of the solid substance in a single plant and its organs.

I have translated and append chart to my report as a sample of Germany accuracy and minuteness in scientific observations.

The above observations on the growth of the maiz plant cannot be regarded as constituting practical experiments, their purpose being purely scientific.

Other German pamphlets in my hands set forth the more practical results of similar researches made under Dr. Kreusler's direction. Their titles are as follows: Observations on the behavior of Cane Sugar under the Influence of Light; Examination of a Chalk Stone from the Bowels of a Horse; The Influence of the Nitrogen and Phosphorous in Manures on the composition of Grain.

The last pamphlet contains numerous tables showing the amounts of nitrogen and phosphorus found in various manures by quantitative analysis, and tables also exhibiting the amounts of the same substances found by analysis in grain raised on soil fertilized by the same manures.

Many other practical and scientific experiments are published in the Yahrbücher (annual reports), notably one by Dr. Eb. Geiseler and Dr. Hugo Werner on the trial of machines, specially a machine for the raising of cream on milk by centrifugal motion.

CONCLUDING REMARKS.

It would be fortunate for the colleges of agriculture and mechanic arts in the United States if those who are interested in their success were thoroughly acquainted with the plan and purpose of the agricultural academy at Bonn. Such an acquaintance would certainly tend to harmonize opinions respecting American agricultural schools, which are now various and conflicting.

In concluding my report allow me to indicate, simply and concisely as may be, two or three general features wherein the institution at Bonn

differs widely from the kindred schools across the water. It will be seen that these contrasts result from the different conditions of society in general and of education in particular in the two countries.

In the first place, the course of study in this German academy covers two years only; and yet it is able in that time to carry its students further in the various sciences that underlie agriculture than can the American schools in their four-years' course. The reason is obvious. Education is more specialized in Germany than in the United States. In other words, the Prussian Government has supplied a special school for every kind of culture in the technical sciences, and it demands that the student shall complete his general education before he enters upon a special one. Accordingly the Bonn Agricultural Academy requires that every applicant for admission to its classes shall either be a graduate from a Realschule (high school) or have gone through the first two years of a German gymnasium; and either of these is equivalent to the first two years in the best of our American colleges.

As a consequence this agricultural academy begins when the second year of the American agricultural closes; and the German student of agriculture is, therefore, able on his entrance to engage at once in the study of such branches as economic botany, agricultural chemistry, the anatomy and physiology of the domestic animals, &c., because he has such general knowledge of botany, chemistry, and anatomy as prepares him to grapple with the special branches of these that are related to agriculture. From lack of schools and time and means the American student of agriculture has no such preparation. Under the pressure of hard necessity, especially in the West, he is compelled to enter one of the State colleges of agriculture and mechanic arts, and to study there the general industrial sciences before he can reach their special applications to agriculture. And the colleges themselves are compelled to give such general instruction in science by the inflexible condition of things.

If they would refuse, their empty laboratories and lecture rooms must be given over to the owls and the bats. They must inevitably include in their curricula the general sciences as preparatory to the special ones. And the only course left, while yielding to the pressure of a public necessity, is to take advantage of every favoring influence to push forward, rapidly as they may, toward the ideal of an agricultural school pure and simple. This they are actually doing year by year. Those who critcise our national schools of agriculture and mechanic arts established in the different States, see clearly and justly that they should properly teach the professional sciences only, but they fail to see with equal clearness that the obstacles to such exclusive instruction are as yet insurmountable. Justin Morrill, however, saw this with the foresight of a statesman, and accordingly so framed the law which gave birth to the national colleges, that branches other than the technical ones could be admitted.

But there is another feature in the conditions of admission to the Bonn school quite worthy of our attention. The applicant for entrance is required to have had practical experience in the operations of the farm. He must have had actual practice in plowing, planting, cultivating, and gathering the crops and managing the stock; in short, be familiar with all the details of farm work, for the authorities regard the innumerable farms of the country as the best possible schools for teaching the mere handicraft of farming. Students in the school at Bonn are therefore not required to engage in manual labor. There is a farm of 50 acres, described above, on which the various field and garden products are grown and used as apparatus for illustration in teaching. They have also, as we have seen, 12 acres set apart for the purpose on which detailed experimentation in various crops is carried out. I perhaps ought to add that this school is not open to the peasantry.

Another of the interesting features of this institution is that all its teaching is strictly and thoroughly scientific. The instruction given in the sciences, on which each branch of agriculture is based, is broad and exhaustive. Forestry, for instance, is taught not simply as an art, but as a concrete science, or rather as a group of sciences, such as botany, physiology of plants, entomology, chemistry of soils, climatology, &c. Horticulture, again, is treated as another cluster of closely related sciences, among which I notice such subjects as heredity in plant life, reversion, cross-breeding in the production of new varieties, close-breeding, &c. Surely the policy of this agricultural academy is an answer to those who urge that the standard of scientific instruction be lowered in the American schools of like character.

ROYAL INSTITUTE FOR FRUIT AND WINE CULTURE.

This school, which was established by the Prussian Government, ten years ago, illustrates the liberality with which special technical education has been provided for in Germany. Its purpose is to make experts in the management of fruit gardens and vineyards; to find by experimentation better methods and more valuable results in fruit and grape culture; to investigate the diseases and insect pests of the various fruits, and to improve the quantity and quality of all fruit crops by the production of new varieties.

For the attainment of these objects the Royal Institute has a special equipment, which is ample and complete. In the first place, the school is happily located at Geisenheim, on the Rhine, which is the center of the grape-growing district. Its faculty is composed of men each of whom is widely known as an authority in the specialty he has in charge. Its experimental grounds are extensive, well-stocked, and minutely cultivated, each division being under the care of a special expert. Its buildings are convenient and adapted to their purpose. The houses for

the propagation and protection of plants, though not extensive, are well designed and give evidence of skillful management, and the full collections found in its museum, laboratories, and cellars are calculated for practical illustration rather than scientific display.

A brief statement, embracing the organization of the Royal Institute (Köninglichen Lehranstalt), its courses of study and general equipment, will properly preface an account of the details which I gathered from personal inspection.

THE FACULTY.

Director Goethe, general executive: Landscape gardening, espaliers, fruit and wine culture, fruit experimentation.

Dr. Müller (Churgau), director of botanical garden: Botany, anatomy, physiology, morphology, and classification of plants.

Dr. Moritz, chemist: Analysis of wines, vines, &c.

Dr. Droysen: Chemistry, zoology, physics, mineralogy, analysis of plants.

Herr Seucker, lecturer on wine culture: Manager of experimentation and cellarage.

Herr Seeligmüller, head gardener: Ornamental plants and vegetables, woodcraft, mensuration, leveling, fruit and plant drawing.

Herr Göbel: Book-keeping.

STUDENTS.

The number of students is limited by law to fifty—twenty-four seniors and twenty-six juniors. Among these are practical gardeners, who are attending the Institute to complete a one year's course which is especially adapted to their wants. But the larger number are young men who come, some with practice in the rudiments of garden operations and some without such practice, and remain two years, at the end of which time, having received their diplomas, they go into gardens for further practice, and finally take charge of gardens either in Germany, France, or England.

In addition to the above there are occasional transient students who enter and remain a few weeks, more or less, to attend lectures on a special part of the course, or on single subjects.

INSTRUCTIVE LABOR BY STUDENTS.

All students are required to labor in the garden, without pay, from 2 p. m. to 7 o'clock in the summer semister, and from 1 p. m. to 4 in the winter semister. The student at the beginning of his course is set at heavy tasks, which do not require skill or experience, but his work gradually takes in the higher processes and finally includes thorough practice in all the artistic operations of the gardener's art. In the two years' course in manual practice the learner is continually under the supervision of an officer, beginning as a common laborer and closing as an expert. Prof. Seeligmüller assures me that this large amount of

manual practice is indispensable to the making of accomplished gardeners

The school year begins with the opening of the summer semister on the 1st of April, when applicants are admitted; the winter semister begins after the summer vacation on the 1st of October, at which time, I am told, no new students are received.

Vacations of a month and three weeks, respectively, occur in September and at Christmas, Easter and Whitsuntide.

EXPENSE.

The expenses of the student, including room and boarding in the public hall, tuition, &c., are 300 marks ($75) per year, if a Prussian; for a foreigner, 350 marks ($87.50) per year. Outside students pay an annual tuition for first and second semisters of 60 marks; for third and fourth semisters, 45 marks; and for fifth and sixth semisters, 30 marks.

CONDITIONS OF ADMISSION.

All students, except practiced gardeners and transient pupils, are required as a qualification for admission to have passed the second year of a German gymnasium or a Realschule of the first order, or to have gained an equivalent preparation in other like institutions.

THE COURSES OF STUDY.

It will be seen that the subjects of instruction and practice are all special, covering thoroughly the ground outlined in the charter of the Institute, but kept well within it. There are three courses corresponding to the three classes of students mentioned above.

I.—Regular course of two years for students prepared at the Gymnasium or Realschule; students who come without previous garden practice remain three years for this course.

II.—One year's course for practiced gardeners.

III.—Different short courses for transient students.

I.—The two years' regular course includes the following:

A. Practical sciences.

1. Botany, including anatomy, physiology, morphology, as applied in fruit and vine culture, in special connection with *plant diseases.*

2. Chemistry, as applied to fruit, vine, and garden culture. Analysis of plant structure and the composition of manures.

3. Physics, embracing the principal laws of mechanics, light, heat, and meteorology, as related to fruit and grape growing.

4. Zoology, as treating of all the animals which affect the growth of plants, specially the insects which are helpful and harmful to fruit and grapes.

5. Mineralogy as comprising the minerals and earths in their relation to the composition of soils.

6. Mathematics, limited to planimetry, stereometry, trigonometry, so ar as applicable to land surveying.

B. Horticultural arts.

1. Fruit culture, comprising the art of fruit raising, fruit breeding and management: the pruner's art, espalier and other forms, fruit classification, the varieties, the profits of fruit raising, diseases and enemies of fruit trees and the vine.

2. Vegetable culture in connection with forcing, including fruit and vine propagation.

3. Market gardening.

4. Landscape improvement, the laying out, beautifying, and management of public parks and grounds.

5. Floriculture, the production and management of ornamental plants.

6. Wood craft, including the nursery treatment and increase of the principal varieties of woods, with a study of their habits.

7. Plant drawing and fruit painting.

8. Field measurement and leveling.

9. Vine culture, wine making and cellarage, management and improvement of the vine; planting and training; classification of varieties; espalier training of the vine; trellising; grape gathering; treatment of the vintage; handling of wine; diseases and enemies of the vine; management of cellars; statistics of wine making and marketing; deterioration and adulteration of wines; standard for the preparation of wine and cellarage.

II. One year's course for practiced gardeners.

The practiced gardeners taking this course must have had two years' practice before entering. They take part in both the practical and theoretical instruction of the regular students, though of the latter only in so far as their former education will permit. For instance, they do not study physics and chemistry, but botany and physiology. This course generally lasts but one year, though students may continue in it longer.

III.—The hospitanten or transient courses.

a. Course of four weeks in horticulture and orcharding: This course is conducted in March, and lectures are given on all branches of horticulture, but especially on orcharding. It includes such subjects as growth of the fruit tree, pomology, preserving of fruits, nursery work, physiology of the fruit tree, treatment of old trees in gardens and on roads, diseases of fruit trees, &c.

b. Course of four weeks for laborers who do the general work on fruit trees in gardens and on public roads: These are taught the practical methods of management; they do not study the theoretical part of horticulture.

c. The course for vine culture and the keeping of cellars: The students of this course receive lectures on such subjects as the propagation of the vine, culture in garden and vineyard, training on walls and houses, grafting, manuring, laying out of vineyards, pressing, keeping in cellars, diseases of grapes, physiology of the vine, chemistry, and analysis of

the vine, &c. They also witness practical demonstrations in the vineyard here, make excursions to other vineyards and wine cellars, work in the press room, the wine cellars, and the laboratories, especially the course in vine culture, and make many extensive microscopic examinations.

Besides entering these named special courses, any transient student may enter and study one or more subjects of the regular course, including laboratory work, remaining as long as he likes. The tuition for transient (or hospitant) students, if they stay for a long course of study, is the same as for regular students; if they enter for one month, 15 marks.

THE BUILDINGS.

The four buildings of the Institute are situated in a group in the highest portion of a 5-acre park which slopes gently and evenly toward the Rhine. The main building, 40 by 80 feet and three stories high, contains the office of the director, library, lecture-room, museum, and drawing-room; a large wing on its western side is used as a microscopical laboratory. Behind this are two structures, the smaller of which serves as a tool-house and barn, while the larger one is occupied by the vintage and pressing-rooms, over which is the chemical laboratory. East of these is a two-story building, the residence of one of the professors, and beyond this, still further east, are the conservatories. The buildings are all of brick and are well adapted to their several purposes.

West of the main building a large arbor, covered with choice varieties of grapes, leads to the entrance of the mother garden. The grounds are well platted and contain a great variety of trees and flowering shrubs and many ornamental dwarf forms of fruit trees.

THE EXPERIMENTAL GROUNDS.

In giving an account of the experimental grounds and their contents I shall adopt the less formal method of describing things as I saw them, making frequent reference to the simple diagram appended to this part of my report.

On the morning of November 1 my card and a brief note, sent to Director Goethe the evening before, was answered by a courteous invitation to an interview in which that gentleman kindly offered to help me in all possible ways to gather the facts I had come to learn. He added that whenever I wished to inspect the experimental garden the head gardener, Professor Seeligmüller, would be at my disposal.

Accordingly the next morning I found myself, under the guidance of Professor Seeligmüller, standing within an inclosure of 20 acres which is called

THE MOTHER GARDEN,

and is used for experimentation in the large and the small fruits, exclusive of grapes. This mother garden occupies a slope which inclines to the south, and stands some 50 feet above the village on its front. In outline it is an oblong figure approaching a parallelogram, its sides

somewhat irregular and its length nearly twice its breadth. (See plate.) The entire garden is surrounded by a high, well-kept hedge, with gates that open upon the main drive.

A glance at the plate will reveal the plan on which the ground is laid out. A straight gravel road, 13 feet wide, runs through the center east and west and is intersected by walks (also graveled) on each side at such distances from each other as to divide about half the garden into plats of various sizes for the growth of different shrubs and trees. Gravel roads of the same width extend around the entire garden on the outside along the hedge. Two other similar roads cross the garden north and south at right angles with the central one, all opening into the two graveled circles, 70 feet in diameter, represented in the cut. At convenient intervals near the walks are large open tanks for watering which are supplied through pipes from the mountains.

Entering the grounds at the west gate, we observe on the left border of the central road two parallel rows of dwarfed apples, extending from the gate to the first circle. These dwarfed apple stocks have stems 12 inches high and generally two opposite branches 12 feet long, supported by a horizontal wire a foot from the ground. The stocks are set along the border 24 feet apart, and the two branches growing in opposite directions extend over the intervening distance and touch each other. The pair of dwarf trees that terminate the rows at each end of the border have, for an obvious reason, but a single 12-foot branch extending inward. Along the border of the outside road *a*, which meets the border just described at an obtuse angle, run two rows of pear stocks dwarfed in a similar manner.

This form of dwarfing, which is used only for apples and pears, is called the cordon horizontal, and is said to be an effective stimulator of productiveness. Professor Seeligmüller informs me that for the perfection of its fruit no other dwarf form excels the cordon: that two weeks ago, before these were gathered, apples and pears of rare size and beauty hung at short regular intervals on these horizontal branches, and that each tiny tree bore about a bushel.

The professor afterwards showed me a few specimens of the Reinette apple (Der Grasser Casseler) which were the product of a cordon horizontal, and they were remarkably excellent in form and quality; and at dinner yesterday with the director I found half a delicious Duchesse pear from a dwarf cordon to be quite sufficient for my dessert.

Along the border on the right of the road opposite the cordons stand high wire frames supporting espalier apples and pears, which display a great variety of forms, the product of the pruning knife. Among these are fine examples of the palmates, the fanshapes, the diagonals, and the uprights, and horizontal-parallels. The precision with which, in all these forms, the opposite branches are balanced is admirable, and the trees when loaded with their uniform rows of fruit make a striking picture. "Cultivated soils and improved varieties," says Professor Seeligmüller, "are indispensable in the raising of fine fruits, but the

final means for gaining the highest excellence is the knife." All the borders of the central roads which divide the mother garden into its larger sections are filled with these espaliers, representing the multitude of shapes known to the pruner's art.

But let us glance at the various experimental trees and shrubs contained in the plats. No. 1 (see plate) is a triangular piece of ground occupied wholly with diminutive cordon apples and pears. The tiny trees are trained in rows, as on the borders, which run in close parallels with mathematical exactness.

No. 2 indicates five large plats (each 10 rods square) which lie on both sides of the central road, and are planted with standard apple and pear trees representing some three hundred and fifty or four hundred varieties under experiment. These standards have also all taken their shape from the pruner's hand, presenting to the eye samples of regular pyramids, spindles, cones, and globes.

Between the rows of apple and pear trees in the plats described grow the whole catalogue of improved strawberries, gooseberries, and currants, all being under trial as to the comparative values of their yield in quantity, quality, and size.

No. 3, a section of one of the plats on the north side, is a small nursery (Baumschule) wherein fruit stock is grown until ready for transplanting, and No. 7, on the southeast corner, is a patch of experimental raspberries.

Farther on by the central road we come upon two large squares (marked 4) which occupy about half the mother garden, and constitute its main experimental orchard. The trees, which are in excellent condition, are high standards (hochstammig) apple and pear. One sees from the uniformity of size and outline which these trees present that they have likewise taken their form from the pruning knife. Along their front (No. 6) stands an assortment of beautiful apricots.

Finally we reach the long narrow strip of about 2 acres on the eastern boundary wherein grow in uniform rows all the varieties of cherries and plums which are found in this latitude the world over. The trees are large, healthy, and strong, especially the plums, and though the season has been unfavorable from excessive rains the fruit was very excellent and abundant. The curculio in Germany is unknown.

THE RESULTS OF EXPERIMENTATION IN THE MOTHER GARDEN.

Though the mother garden has been cultivated a few years only the results already obtained are sufficient to prove the value of experimentation in fruit production when carried on with the requisite skill and with conditions that are under control. These results may be briefly indicated here, though many of them only confirm similar conclusions which have been reached elsewhere and so have become the common possession of professional gardeners.

Dwarfage.—Among the effects of pruning, Professor Seeligmüller finds that the finest fruit is obtained from the most diminutive trees. In other words, the perfection of the crop is, within certain limits, in proportion to the extent to which dwarfing has been carried. Accordingly the cordon horizontal dwarfs have produced the finest samples of apples and pears yet reached in the mother garden. They are suitable for apples and pears only.

The espalier forms, though they uniformly quicken fruit growth, are available mainly as a protection to tender varieties which suffer from the severity of the climate. Examples of the peach espalier are seen in the park behind the buildings.

Of the four hundred varieties of pears tested on dwarfs and standards, fifty are found to be of the highest excellence for dessert and fifty for cooking. Some two hundred other varieties are moderately good.

The apples under experiment for comparative excellence include also nearly four hundred varieties; of these fifty varieties have received the indorsement of the Institute for the German orchards and fruit gardens. The professor mentions as the very best of these for budding the following sorts: Gold Pearmain, Canada Russett, Grubensteiner (fall apple), Gray Russet (winter apple), Landsburg (winter apple), Grosser Bohm, Cossler Russet, Red Eiser apple, Prince apple, Red Herbst Calville, Red Winter Calville, White Winter Calville, Virginia Rose apple, Yellow Belleflower, St. Germain, Karl apple, Schwert Gregoin.

The following sorts have been used for dwarfing, especially for the cordons: Baumann Russet, Landsburger Russet, Canada Russet, Gold Pearmain, White Winter Calville, Red Winter Calville.

Of peaches from the fifty varieties, one dozen pass muster. Of twenty-four kinds of apricots, twelve are approved. From sixty sorts of cherries and plums, twenty-five of each are pronounced good and thrifty. The following cherries are specially commended: Black Eagle, Early May, Buettneis Gebbe Knorpel Kirsche, Grossa Bunte Hertz Kirsche, Westhoefler Knorpel Kirsche.

SMALL FRUITS.

The list of gooseberries in the mother garden contains sixty varieties, including the large English sorts, some of which are without names. All these varieties are infested with shield louse and all have mildewed during the prolonged summer rains. Nevertheless some of the fruit, as drawn from actual samples and represented on plate 2, is certainly remarkable in size.

Raspberries.—Forty-five varieties. Out of these twenty-five chosen as suitable for garden in Germany.

Strawberries.—One hundred varieties in cultivation, of which a dozen only are accepted as first rate. The plants throughout are strong and healthy.

To the above summary of results reached in the mother garden should

be added the experiments on the different willows in which several sorts have been found best for the following uses:

1. *Salix aurea* (Golden willow); for baskets and boxes.
2. *Salix arundifolia* and *S. glauca*; for baskets.
3. *Salix uralensis*; for framing.
4. *Salix amygdalina*; for all uses.

NEW VARIETIES PRODUCED IN THE MOTHER-GARDEN.

The production of new varieties, especially of the larger fruits, is proverbially slow. It requires at least ten years from the process of hybridizing to arrive at the final result in the condition of new fruit, and the Royal Institute has not been in operation longer than that period.

Many new apples and pears and a large number of seedlings show excellent promise, but have not yet reached fruitage.

Four new sorts of raspberries have been produced by the director and have proved valuable additions in raspberry culture; also four new varieties of gooseberries. In this department of work Director Goethe has, furthermore, attained results in the crossing of strawberries that are very striking. I take the following description of four he has obtained from the director's own lips:

The first, which he calls King Charles, is 1½ inches in diameter and excellent in quality.

The second is "Crœsus," oblong, 1½ inches long, very early and sweet, an abundant bearer. In a warm spring it ripens here by the 1st of May. Its parents are Wilson's Albany and the Beehive. The Beehive must be full of honey to have neutralized the acid of Wilson's Albany and produced a "sweet" hybrid.

The third, which is christened Bismarck, is globular, 2 inches in diameter, a good bearer, and of first-rate quality.

The fourth, Director Fürer, so named, is cockscomb in shape, flat on the bottom, light red in color, and excellent in flavor.

BRIEF NOTICE OF THE PROCESSES PRACTICED AND TAUGHT IN THE MOTHER GARDEN.

All those operations which belong to the management of trees, both in nursery and orchard, are here performed in a thoroughly scientific manner. The students are required to work at budding and grafting, transplanting, pruning for standards and the various dwarf forms, including all kinds of espaliers and cordons.

Budding is used principally on dwarf varieties for cordon making, the object being to train the tree from the very beginning; the same result can be reached by root-grafting, but not in such perfection. For apples summer budding in August is practiced. The bud is set in about an inch above ground, two-year-old stocks being used. This process is

usually the work of students under instruction, and the healthy condition of the young trees was an excellent proof of their skill.

The mother garden is as much used in educating the students in the practical operations of horticulture as is the lecture room in teaching the sciences which underlie it.

THE EXPERIMENTAL VINEYARD.

Crossing the road near the northeast corner of the mother garden, we enter the experimental vineyard, whose outlines are given in Fig. *c*, plate 3. This interesting inclosure, comprising 8 morgans or 6½ acres of land, rises above the garden and slopes downward towards the Rhine with a sharper angle. Standing within it one sees behind him on the north the vine-covered steeps rising terrace above terrace to the mountain top, and in front looks down on the red-tiled roofs of Geisenheim and the huge rugged masses that rise beyond it. The soil is a rich red loam, with abundance of lime, and is said to be the best possible for the growth of the wine grape.

The entire area is divided by graveled roads into eight parallelograms of 1 morgan each, five of which (marked 2) are planted with the Riesling and other well-known vines with which the vineyards on the Rhine are usually stocked. The grape crop, which is not yet gathered, is large, being much above the average in this unfavorable season. The stocks, which stand from 3 to 4 feet high in rows 3 feet apart, are seemingly vigorous and healthy.

Three of the plats are devoted specially to the solution of the numerous problems in vine culture. No. 2 is the quarter whereon are tried different methods of staking, pruning, manuring—in short, it is here that all the operations, tools, and modes of cultivation known in grape culture are compared as to effectiveness. It is also the breeding quarter in which newly-produced varieties are grown and kept under careful observation.

The two plats marked 1 are planted with varieties of the wine grape from all quarters of the globe. Here are grapes from Spain, England, France, Austria, Italy, Southern Russia, and from Asia, Africa and America. The entire collection embraces three hundred and fifty varieties, arranged in artistic order. The two plats are cut lengthwise by graveled walks into long, narrow sections 30 feet wide, across which the vine rows run 3 feet apart from walk to walk. One-half of a single row is assigned to each variety, which occupies twelve or fifteen stakes with its five or six stocks, the last of which stands on the border, and in this way every sort is brought directly under the eye of the observer in passing along the walk. A single vine with its branches is supported by two or three stakes, and the growth is limited by the use of the knife uniformly to the height of 3½ feet. The canes are all seemingly strong and healthy, and though the season has been the worst for the

grape known in thirty years the crop is certainly an abundant one. The grapes hang in clusters of rare beauty, showing the perfection of each variety in quality and size and displaying all the different colors known to the fruit. Such a vineyard can be seen only on this side of the ocean.

RESULTS IN THE EXPERIMENTAL VINEYARD.

These extensive experiments in testing the comparative value of the different wine stocks, to find something better than the old Riesling and the Burgundies, are regarded here as full of promise for the future, but it is not time yet to have reached any final results. The vineyard was planted only four years ago, and two of the seasons since have been wet and cold. The facts settled on so far have been only negative—a host of varieties under question having been pronounced worthless—while in the case of the comparatively few which give signs of great excellence, the final verdict has not yet been reached. The American sorts have been condemned without exception.

The processes in testing the value of the grape for wine are complicated and protracted. In the first place the grape must be grown under the best possible conditions. Then the wine made from it is tested both by chemical analysis and by storage in the cellar. The first test may be finished at once; the last, which is much the more important, requires time for its completion. Thus many years must elapse before this experimental vineyard will answer all the questions that have been put to it.

The following are reported by Professor Seucker, who is the curator of this department, as showing great promise: Black Ebbling, Blue Burgundy, Cabernet Sauvignon, Blue Muskatella, Blue Oxeye, Red Agapantha (very productive).

EXPERIMENTS IN THE OPERATION OF THE VINEYARD.

A brief account must be given of the investigations made by experiments carried on in Plat 2. On this plat, as I have already said, are tested the different operations and materials used in grape culture. The space assigned to my report on the Institute will not admit of full mention of the many matters which are placed under scrutiny here, but a few specimen experiments may be given.

First, the comparative efficacy of various chemicals and other liquids for the preservation of stakes is being extensively tested under carefully-observed conditions. One set of stakes was soaked in chloride of zinc before setting, a second set in sublimate, a third in acid of fat, a a fourth in hot tar, a fifth in vitriol, a sixth charred, and a seventh set in the ground with the wood in the natural condition.

While all the above methods are known to be genuine preservatives, the preference, so far, is given to the tar and the vitriol, a stake soaked

in the latter long ago in another vineyard and subsequently transferred to this having already lasted eighteen years and showing no signs of decay.

EXPERIMENTS IN METHODS OF TRAINING.

An interesting series of experiments is in progress here to determine the most profitable of the numerous methods employed in training.

Of these I notice under trial—

1. One row trained to a single horizontal wire. the vines being 4 feet apart.
2. On single slender stakes. three stakes to a vine.
3. On three horizontal wires, the vines trained straight upwards.
4. Three strong stakes to one vine with strong canes.
5. One stake to one vine.
6. On trellis of wires 8 feet high, with transverse wooden slats.
7. Four stakes to one vine. with extended branches.
8. On one horizontal wire a foot from the ground.
9. The method known as head training.

The common method of training in the vineyards on the Rhine is to use three stakes set 4 feet above the ground for one vine with three canes, each cane tied upright to its stake. one of them being trained for the next year's bearing. The stocks in Rhine vineyards commonly last thirty years, and the grapes grown for Rhine wines are the Riesling and the Gestreicher. which are white varieties, the black and the gray Burgundy and the white Gutedel.

TRIALS OF MANURES.

Valuable operations are also carried on in this plat in which the different commercial fertilizers used in grape culture are pitted against each other and against cow manure. wherein the results are greatly in favor of the latter.

DISEASES AND ENEMIES OF THE GRAPE.

Vines which are affected with any disease or infested with insect enemies, are kept under daily scrutiny and different remedies and means of destruction applied, and the effects noted and taken account of.

The dreaded philoxera has not reached the Rhine as yet, but it infests the vineyards only 50 miles away, and its presence here is grealty feared.

The York Madeira, a Spanish grape. is not subject to the ravages of this terrible pest, and consequently all grapes now propagated are grafted on its root.

THE PROPAGATING HOUSE.

The propagating house is a very simple affair, but is perfectly adequate to the purpose for which it was built. It is entirely below the ground, the glass roof resting on the surface. The sides are walled

with brick, and there is a small room for potting and preparing cuttings at the entrance. The house is narrow and long, being about 8 by 30 feet. The roof is quarter pitch and is made of hot-bed sash, which are fastened with hinges at the top so that they can be raised at pleasure. The benches are about 3 feet wide, extending around three sides, with a narrow path in the center. They are filled first with a layer of gravel to insure perfect drainage, then clean river sand, about 2½ inches deep, in which the cuttings are planted. None of the benches have glass covers, but Professor Seeligmüller informs me that for certain kinds of plants a glass covering is used. The beds lie so close to the roof, however, that for most sorts this precaution is unnecessary.

The heating apparatus consists of a closed brick furnace with a grate placed beneath the bench at the entrance, so as to be fired from the potting-room, and a large flue made of tile and perfectly tight, so that no smoke or gas can escape into the propagating-room. This flue runs beneath the benches, around three sides of the house, passing out through the roof of the potting-room. The benches are boarded tightly to the floor, having small doors to the place beneath them, where the thumb pots are stored. This insures a good bottom heat, which is greatest over the furnace and gradually lessens toward the place where the flue passes out. To make this gradation more valuable the space beneath the benches is divided into compartments. In this way with one fire the best heat for several different classes of plants is obtained. Thus I saw grape, lobelia, alternanthera, and conifer cuttings all doing well in the same benches, each having the bottom heat best adapted for its growth. In the winter the room is ventilated through the door only. As the plants remain here but a short time after rooting, the close atmosphere does them no harm; it rather stimulates their growth than otherwise, and hence is not objectionable.

The flue is provided with a door at each corner, so that it can be cleaned as often as necessary. As long as the flue is kept open no difficulty is met in maintaining a temperature of 40° R. (122° F.), though this is never necessary.

As soon the cuttings are rooted they are planted in thumb pots and kept in the propagating-house until the roots show against the size of the pot. They are then taken to the hot-house, cold-house, or planted in the open garden, as may be desired at the time of year.

For ordinary propagation of the coleus, acharanthus, alternanthera, and similar plants, a sand heat of from 20° to 25° R. (77° to 88° F.) is given; for geraniums and roses and the hardier flowers generally, about 15° R. (66° F.) is required.

THE GREEN-HOUSES.

The green-houses, two in number, are built entirely above ground, and both side and end walls, as well as the roof, are of glass. The houses are about 30 by 80 feet in size, and 12 feet high from floor to ridge-

pole, the eaves being about 7 feet. The sides are made of glass doors, which are hinged at the top, opening from the bottom upward. There are small ventilators in the peak of the roof, but these are seldom used. The benches are so arranged as to place all the plants as near the glass as possible; there are some exceptions to this rule, of course, but Professor Seeligmüller insisted that, in most cases, the increased light and sun heat thus afforded is very beneficial to the plants. This is particularly true of young plants, and there are several swinging shelves very near the glass devoted to plants just from the propagating house. Both the hot and cold houses are heated by hot-water pipes, this having been found to be the best apparatus for the purpose.

The collection of plants, though not large, is interesting, and is in very fine condition. There are some noble ferns here—finer than can be seen in the celebrated Palm Garden at Frankfort or the extensive conservatories at Ghent. I was much pleased with the neatness and care displayed by these houses. The hot-house is very luxuriant; the plants are not rare, but they show perfect health, and their arrangement is excellent. The cold-house, of the same size as the other, is occupied by plants in the resting stage, and hence they are not so pleasant to the eye. In this house the geraniums, roses, pinks, and other summer bloomers are stored, and the temperature is kept low so that they will make but little growth. The rest thus gained prepares them the more perfectly for their summer's work.

The above collection is, of course, used as a simple apparatus for instruction, and students are taught the nature and management of all hot-house plants, the care of the green-houses, and especially the art of propagating. In the last they are thoroughly drilled, and become experts at the business before leaving the school.

METHODS OF PROPAGATION.

The propagation of grapes from single buds.—The wood is cut as soon as thoroughly ripened in autumn and kept in sand in the cellar until January or February, when the buds are prepared. The piece taken is made with slanting cuts, beginning half an inch from the bud on each side of it, and meeting opposite the bud. This gives the greatest possible exposure of the inner bark, from which the roots start. The buds thus prepared are planted in thumb pots, which contain, first, gravel, then sandy loam, and lastly pure sand, the latter filling about half the pot. The cutting is placed in the sand diagonally so that the bud rests on the surface. The pots are then taken to the propagating house, plunged into the sand of the benches to their tops to insure the most even temperature and given a bottom heat of about 88° F. The air is kept moist and the pots quite damp. Some varieties, as the Concord, take root within three weeks, others requiring much longer. When well rooted they are transplanted into a somewhat stronger soil and kept in a warm, damp green-house near the glass. In subsequent repottings the young

vines are gradually accustomed to the normal out-of-door conditions, and as soon as may be they are planted out in nursery rows and given thorough culture.

Propagation of conifers from cuttings.—Many species of Retinospora, Cupressus, Thuya, Chaamæcyparus, Biota, Juniperus, Taxus, Thuiopsis, and Wellingtonia are propagated from cuttings. There are two seasons when this may be done: one in September and October, as soon as the new growth ripens, and this is the better time; again in the spring, before the trees begin to grow.

The wood taken should be the new shoots, *perfectly ripened*, and the shorter the better. The cuttings are made with a small portion of two-year-old wood at the base. If taken in the autumn they are planted in the coolest part of the propagating house, and given a bottom heat of 11° R. (57° F.), and from 12° to 15° R. (59° to 66° F.) air heat. They take root during the winter, and after a short stay in the cold-house are planted in nursery rows, where they are well cultivated and shaded during the entire summer.

If the cuttings are made in the spring they are planted in a leaf hot-bed or in a manure hot-bed of low temparture; the leaf bed is more even in temperature and hence is better. They are kept wet and shaded from the sun during the heat of the day. It takes two or three months to root them in summer. When rooted they are potted, kept in a shaded place in the open air, and finally planted in nursery rows and given the ordinary treatment for conifers.

The common method of propagating from base cuttings is practiced in growing grapes, gooseberries, currants, and flowering shrubs. They are here somewhat hastened by planting in a cold frame in the autumn and leaving during the winter; the protection thus afforded prepares the cuttings for an earlier start in the spring.

Winter propagation of shrubs.—The following process in propagating the rarer varieties of flowering shrubs is in practice here: The plants are taken up and potted during the late summer months and kept in a dormant state until about the middle of December. They are then put into the hot-house and watered freely. The buds soon start and grow very rapidly. When the new growth shows five or six leaves it is cut off with a very sharp knife, planted in perfectly clean sand in the propagating house and given a bottom heat of about 25° R. (88° F.). As there is danger of the delicate cuttings "damping off," care is taken that they are never very wet. As soon as they are rooted they are planted in thumb pots and kept in the propagating house until repotting is necessary. They are then removed to the hot-house, and, when again transplanted, to the cold-house and thence to the open air. Many shrubs are grown very quickly in this way; among others, *Prunus triloba*, *P. chinensis*, the Diervillas, many of the Spireas, especially *S. prunifolia*, flora plena, *S. taevigata*, *S. aurifolia*, and *S. piconiousis*.

COLLECTIONS.

All technical instruction requires abundance of apparatus in every department. The completeness of equipment of the Royal Fruit School may be judged of from the following items gathered in a visit to the museum, under the guidance of Professor Seeligmüller.

Remarking that the collections were used solely as apparatus in teaching, the professor called my attention to—

1. An extensive collection of minerals arranged to show the constituents of different soils.

2. A great variety of woods showing diseases caused by insect ravages, and along with these magnified plates of the insect itself, its eggs and metamorphic forms.

3. An exhaustive collection of the helpful birds, beautifully mounted, together with their nests and eggs.

4. The Aethiope variety of cherry infested with the larvæ of the wasp.

5. A large collection of vines infested with different parasitic fungii.

6. Many gooseberries covered with the shield louse.

7. A large collection of specimens of dried fruits.

8. Twenty-five varieties of hazel-nuts raised in German gardens for the market.

9. A full collection of grape, apple, and pear seeds.

10. An assortment of diseased plants preserved in alcohol, one of which shows the ravages of phylloxera.

11. *Gymnosporangium fusorum* (a minute fungus) on leaves of pear tree.

12. A collection of the seeds of ornamental trees and shrubs.

13. A collection of insects harmful to fruits.

14. A collection of grasses and garden plants, one thousand species and varieties.

15. A vast collection of leaves, with descriptions, neatly catalogued; among these I noticed all the oaks of Germany.

16. A complete collection of wax casts, made under the direction of Professors Goethe and Seeligmüller, representing three hundred varieties of apples and corresponding lists of other fruits, large and small.

THE CHARACTER AND METHODS OF INSTRUCTION.

The instruction given at Geisenheim, though its range is limited to the purpose in hand, is very exhaustive and minute. Each science in the course is taught exclusively by lectures, in which its bearing on the gardener's art is never lost sight of. The pupils take copious notes and study books of reference wherein the topic under consideration is treated, and their thoroughness is tested by frequent examinations.

The manual arts in fruit and grape culture are taught by actual practice in the mother garden, the experimental vineyard, the museums, and the conservatories, where the principles and processes explained in

the lecture-room are applied by each pupil under the supervision of the head gardener.

Two objects are kept constantly in view throughout the two years' course:

1. That the student shall be thoroughly grounded in the sciences that are applied in the art of gardening.

2. That he shall attain the highest possible skill as an operator and an expert.

The course of labor in the gardens is carefully adjusted to answer the latter purpose. In the operations which constitute the garden practice there is a gradual progression from the simple to the more complex; every task is not only important in itself, but is preparatory to that which follows, and the most difficult arts lie latest in the series. There is no operation known to gardeners, says Professor Seeligmüller, which our graduates cannot perform; and I find abundant proof that the assertion is correct.

The knowledge of the higher operations of the garden, orchard, and vineyard are not gained through observations solely, or through what are called demonstration lectures. Not only is a large share of the ordinary work done by the lower classes, but the higher classes carry through and repeat the more difficult processes until they acquire the accuracy and facility of experts. Grafting by students, budding, espalier training and pruning, dwarfing, pruning in all its forms, and all the processes of propagation may be mentioned as the simplest examples. And we may gain a still further insight into the practical character of the drill given here from the fact that not only are all the abstruse branches of plant heredity taught thoroughly, but corresponding practice in their management is furnished to the eye and the hand of the learner.

The skill shown by the class under Professor Seeligmüller in the drawing and coloring of plants and fruits was also worthy of the highest commendation. Their color drawings were so far beyond the stage of elementary instruction that as imitations of nature in form and color I have never seen their equal in the school-room. And the wax models of large and small fruits, which are displayed in the museum as the work of seniors, are equal in beauty and accuracy of imitation to the best of those shown at our Centennial Exhibition at Philadelphia.

The following skeleton of a lecture by Dr. Goethe, to which I listened, may serve to give a more definite notion of the method of teaching, which, as before stated, is confined to lectures and frequent examinations.

This lecture was given to twenty-four members of the freshmen class, who rose when we entered the room at its beginning, as also when we left at its close. The director spoke slowly and distinctly, in simple German, drawing rapid illustrations on the blackboard, and stopping

to ask an occasional question. The class listened with close attention, making constant entries in their note-books.

The subject was the methods of preserving fruits, and the lecturer began by saying that the ordinary way of keeping fruits, either for cooking or wine-making in the autumn, is to make moderate sized heaps on ground, a little elevated, and cover them lightly with leaves of trees, &c.

2. To keep large fruits (apples, pears, &c.) through the winter, put the perfect specimens, well cleaned, into large earthen jars that have been fumigated with sulphur. Then let the jars stand open until the evaporation is completed, when they should be covered tight and buried 20 inches under ground.

3. To preserve the more valuable varieties, wrap each sample in paper, place in dry room or bin, and cover with cut straw a sufficient depth to prevent freezing.

4. Another method is to cover the fruit with clean washed dry sand, in such a manner that they do not come in contact with each other.

Among the numerous methods of keeping grapes the following are the best:

1. Dry the bunches, burn the ends of the stems, and hang them up in a dry room.

2. Take small branches with clusters hanging on them and keep the cut end in a bottle of water impregnated with charcoal. This method is much used by the French.

Then followed a description of the different ways of packing and boxing for transportation to distant markets, which do not differ from those used in the United States.

WINE CELLARS AND LABORATORIES.

Proceeding now to the building containing the laboratories we visit first the five cellars below, wherein experiments are made in the keeping of wine under different temperatures. In each of these is a large fass of wine, the quality of which is noted from time to time, under a given degree of heat. In still another compartment are kept the assortments of wine made from the grapes of the experimental vineyard, and in the spacious press-room (kelter-haus) further on stood five different wine presses for trial as to comparative merits; also a number of wine pumps, marking apparatus, a variety of fasses, grape grinders, &c.

Ascending next to the laboratory above, we pass through several rooms which are used by students for making analyses of plants to find their constituent elements.

We enter next the general chemical laboratory, consisting of three rooms well furnished with apparatus necessary for the work in hand; among them are highly finished balances made by Giessen, Berlin. In this laboratory, which is in charge of Dr. Maritz, are the facilities for the extensive series of analyses which are coextensive with the experi-

ments in progress, thus furnishing confirmatory tests. In this complete system whatever product is under scrutiny in the garden reveals its components to the expert in the laboratory. I am told that no new fruit grown in the mother garden, or wine from the experimental vineyards, receives its final verdict until the laboratory has passed judgment upon it.

LIBRARY.

Leaving, without special notice, the fruit cellars, which correspond in their extent and arrangement with the general equipment, we come finally to the library, a feature in the outfit of a technical school which is quite as indispensable as the experimental grounds and other apparatus. This library, which occupies a room in the central building, contains four thousand volumes on practical gardening and the sciences connected therewith, including, indeed, all the copious treatises on these subjects printed in the German language. In this library is found, moreover, every well-conducted journal on gardening which is published either in German or in the other languages.

THE ROYAL FOREST SCHOOL OF BAVARIA AT ASCHAFFENBURG.

This institution, which I visited on the first week of December, 1882, is devoted to the preparation of young men for the Royal Bavarian Forest Service. It is in reality a preparatory school, in which the student is fitted for entering in the department of forestry in the Bavarian University at Munich, where his education in this professional line is completed. The extreme thoroughness with which forestry and its allied sciences are taught here may be gathered from the extent of its curriculum and the preparation necessary as a condition of entrance.

The candidate for admission is required to have made the same attainments in general education as are demanded by the Royal Agricultural Academy at Bonn, namely, that he shall have completed the studies of a realschule or half the course of a Gymnasium. With such an intellectual equipment he engages for two years in the studies that underlie forest growth and management and the practice of all the operations and handicrafts connected therewith.

The staff of instruction consists of—

1. The director, Dr. Fürst.
2. The royal forstmeister of Kleinostheim.
3. The professor of physics and mensuration.
4. Professor of mathematics.
5. Professor of botany.
6. Professor of zoology.
7. Professor of chemistry and mineralogy.
8. Teacher of drawing, who is also librarian.

9. The assistant in the laboratory and curator of the botanic garden.

The director is the supreme executive. He is responsible not only for the general order and discipline, but for the instruction given by the professors in woodcraft, &c.

Every branch in the curriculum is taught by lectures, with abundant illustrations from the scientific and practical collections.

The following are the subjects which comprise the sciences that are grouped around woodcraft and forestry, and which occupy two years:

1. Elementary mathematics, including algebra, geometry, plane trigonometry, and polygonometry.
2. Experimental physics, including universal and physical mechanism, heat, optics, magnetism, and electricity.
3. Inorganic chemistry.
4. Mineralogy.
5. Botany.
6. Zoology.
7. Forestry proper.
8. Stereometry.
9. Spherical trigonometry.

It must be understood that the above sciences are studied especially in their application to forestry and woodcraft. The chemistry, for example, is made to develop, by analysis, the laws and operations of vegetable growth, the chemical composition of the various woods and the soils on which they grow. Botany, which is extensively and thoroughly taught, embraces specially the nature and classification of the products of the forest; and zoology, while it is broadly grounded in a general knowledge of the laws and facts of animal life, is directed particularly to the animals that inhabit the woods. Forest entomology is studied minutely.

Throughout the course great pains are taken to bring the student into contact with the natural objects which illustrate his studies, and extended excursions into the woods and fields are made statedly, under the professors of biology and woodcraft.

Examinations are frequent, and upon the student's standing in these depends the diploma which admits him to the department of forestry in the Royal University at Munich.

There are in attendance some 85 students.

BOTANIC GARDEN.

Adjoining the main building in the rear is the botanic garden, an inclosure of about 2 acres, which contains the different species and varieties of native forest trees and shrubs, each designated by a metallic label giving its botanical name.

On the east side of the inclosure stands a small building containing the collection of woods, put up in a form to show the graining, the layers of growth, the adaptation to polish, &c.

THE EXPERIMENTAL GROUNDS.

As my visit was made during the great floods which prevailed throughout the middle and south of Europe, the experimental grounds were so covered with water as to be inaccessible. Dr. Fürst informed me that these grounds embrace several acres, and that the habits and hardiness of all the trees that grow in open air in this latitude are being tested thereon, and that the preparation of soil, planting, and culture of each is carefully adapted to its nature and mode of growth.

I regret to say that I waited at Frankfort three weeks to find an opportunity for visiting these grounds, but waited in vain.

LABORATORIES AND COLLECTIONS.

The museums and laboratories, which occupy convenient rooms in different parts of the building, contained the following collections:

A. A full collection of instruments in geodesy, in which are all the old and new measuring and leveling instruments, such as tables of measurements, theodolites, compasses, &c.

B. The physical collection, which includes abundant means for demonstration by the lecturer, such as technological models, a large number of instruments for measurement and experiment, cathetometers, spherometers, many kinds of balances, aerometers, barometers, thermometers, instruments for measuring moisture, microscopes, magnetometers, bateries, and different galvanic instruments.

C. Mineralogical collection, embracing a great variety of fossil forms, and a geological collection which contains the local minerals and rocks, especially those in the neighborhood of Aschaffenburg. Also a great variety of petrifactions, comprising specimens in botanical and zoological paleontology.

D. The botanical collection, which is made up of the native woods preserved in disks and longitudinal sections. Also a complete collection of fruits and seeds of forest trees, a smaller collection of plates representing the diseases of the native woods, and a beautiful collection of fungus models and dried fungii, a general herbarium, a small collection of fossil plants, and an interesting variety of wax-plant models for instruction. To the above may be added the plants and trees of the botanic garden, whereby are taught the actual habits of plant growth in the different families. To these may be added the plants in the greenhouse, where, in two rooms, hot and cold, the foreign plants are grown and used for demonstration by the professor.

E. The zoological collection, which has been made for practical work rather than scientific completeness, embraces neatly mounted specimens of all the birds and animals that inhabit the forests of Germany. Among these the various animals pursued in the chase are conspicuous; in addition, a systematic collection of anatomical specimens preserved in spirits, and dried preparations of many types of the lower orders in

the animal kingdom. especially those which include the parasites of men and animals—in fact, the entomological department is very full. The above collection contains also many models of glass and papier-maché, representing the various lower animals, the anatomy of the horse, &c. There are many specimens, moreover, for microscopical demonstration.

F. There is a large collection of arms and instruments employed in the chase.

G. A full variety of means for instruction in drawing, consisting of models, engravings, leaf and flower forms, &c.

H. The library is exclusively a professional one, consisting of works on practical mensuration and on every branch of physics, chemistry, mineralogy, botany, zoology, the hunter's art, and the science of forestry. It is fully supplied also with works on agriculture and management of estates.

THE AGRICULTURAL STATION AT GHENT, BELGIUM.

The Agricultural Station at Ghent is one of nine similar establishments sustained jointly by the Government of Belgium and local agricultural societies. The building in which it is located is moderate in size, and contains two offices, a chemical laboratory, well supplied with apparatus for analysis, a stable having two stalls, and a feeding-room. The working force consists of the director, D. Crispo, and a chemist with his three assistants. The chemical work done at this station is limited to the analysis of the following substances:

1. All foods and products of the farms in the province.
2. All fodders used for the production of meat and milk, for the purpose of determining their comparative values.
3. All manures, especially the commercial fertilizers purchased and used by the Belgian farmers.

Director Crispo says that the small farmer of Belgium is shamefully imposed upon by the venders of spurious fertilizers and feeds, which absorb the profits of the farm. When he applies to a guano merchant he gets a worthless mixture of phosphate, sand, and damaged guano; if he seeks for nitrate, he receives sea salt instead; when he believes he is purchasing oil-cake, they deliver a wretched mixture of dregs. The crops fail, the soil becomes sterile, his cow dies of indigestion; the farmer's losses are the vender's gains.

This evil is evidently the result of ignorance, and is to be remedied by increased knowledge. But how can a poor laborer instruct himself when he must work all day and often even by moonlight? When he has been taught that if guano is good it is not because it comes from a great distance, a peculiar smell and a brown color, that it gives such a stimulus to growth, but because it contains assimilative nitrogen and phosphoric acid; that a white, inodorous fertilizer may be just as good

if it contains the same elements in the same proportion; that between two oil-cakes there is no difference except that ascertained by analysis in respect to their nutritive values, whatever may be their color and composition; when he knows that the microscope and balance can detect what is hidden from plain vision, then he will recognize one of the principal causes of his losses; he will buy with discernment and act with a knowledge of facts.

It is necessary that the Government recognize the legitimate value of these needs and meet them as promptly and radically as possible. The agricultural station located in each of the nine provinces of Belgium is designated to subserve this purpose and to solve other questions that are vital to agriculture. Specimens of commercial fertilizers are brought here by the farmers for analysis and their values accurately determined and every spurious article detected.

EXPERIMENTS IN ANALYSIS OF FOODS, MANURES, ETC.

It is a surprising fact that of late years the honest manufacturers of commercial fertilizers have come to grief because of the extensive sale of counterfeit fertilizers at much cheaper rates. It is the mission of this station to expose the counterfeits and substantiate the genuine commodity by quantitative analysis and to publish the results.

Accordingly this station has made, in a single year, analyses of 1,000 substances, of which 314 were from within the province, and 686 imported.

Of these there were:

Different guanos	168
Sulphates of ammonia	27
Fertilizers	57
Superphosphates	86
Phosphates	156
Nitrates	58
Animal substances	42
Oil-cakes	60
Beet seeds	255
Miscellaneous	91

The most important service which this station has done for its province has been a determination of the quality of various lots of beet seeds offered in the market. The sugar beet is extensively raised in Belgium from imported seeds, some of which are adulterated with valueless mixtures, and some have partially lost their germinative power. The station has determined by accurate methods the value of each sample, and so protected the farmer from fraud. The tests of beet seeds have brought to light the following facts:

On carefully examining a sample of these seeds one can distinguish three different kinds of different sizes: good, satisfactory, and doubtful. The reciprocal proportions, the weight and the germinative power, the number and strength of the germs of each of these three kinds can

be detected and are very different. There is nearly 9 per cent. good, 45 per cent. satisfactory, 45 per cent. doubtful, and 1 per cent. impurities in any given sample. The importance of an experiment which detects the different germinative powers of these three kinds of seeds is manifest.

Analyses have been made also of many foods offered in the market, such as flour, bread, sugars, &c. These analyses have revealed the adulteration of flour by the addition of ground white beans, and the manufacture of impure bread by the use of metallic salts as one of the ingredients.

The chemical experiments of this station have also shown that a mixture of different refuse substances, among which rice and maize predominate, has been used to adulterate oil-cakes, which have been eagerly purchased by the farmers because of their low price.

The station has even turned its attention to counterfeits in commercial fabrics, and has determined, by infallible processes, the precise amount of cotton present in mixed goods. In one piece of vigone, for example, claimed to contain 15 per cent. of wool, only 6.5 per cent. was found.

This station has discovered, moreover, that the saltpeter of Chili is no longer found in the market in a state of purity, the lots which are offered for sale having been adulterated with from 10 to even 50 per cent. of sea-salt.

Feeding experiments conducted at the Ghent station are limited in extent but exceedingly accurate in detail. They consist in the trial of different food mixtures as to their comparative values in the production of beef or milk. The different ingredients of a food mixture are first analyzed and their chemical constituents quantitatively determined. The mixture is then fed by weight at regular intervals to the steer, which, for example, has been selected and weighed.

The excrements of the steer, both liquid and solid, are collected by a device arranged in the floor of the stall and weighed every third day. The expenditure in sustaining animal heat and respiration is also estimated. The steer itself is weighed at the same time. It is evident that the analysis of the excrements will determine what constituents of the food have been expended in increasing the weight of the animal and how much of increased weight has resulted in consequence.

At this time (January 10) two beef steers, which are a cross of the Flemish with the Short-horn, occupy the stalls, and the food mixture which they are consuming contains ground oats and malt refuse, half and half, mixed with chaff to give it bulk. The arrangements for weighing, feeding, and gathering the excrements are convenient and complete.

The cement floor of the stall slants slightly from the outside towards a depression in the center, to which is connected a rubber tube that

leads to a glass reservoir which receives the urine; the solid matter is carefully gathered as it falls.

A large number of mixtures have been analyzed, tried by feeding, and pronounced upon as to their comparative value.

Following is a plan of the experimental stable:

THE HORTICULTURAL SCHOOL AT GHENT.

On the morning of January 11 I left the Hotel Royal, and walking a mile through the quaint narrow streets, found, with some difficulty, the National Horticultural School, which is located in the southeast portion of the city. Passing through a front inclosure of about 5 acres, I found that the apartments occupied by the school were located at the two extremities of a large conservatory, which had evidently been remodeled and changed from greenhouse to class-rooms, museums, &c.

Professor Van Hulle, who has charge of horticulture proper, received me courteously and declared himself at my service for the rest of the forenoon. I gathered from him the following facts, which the rapid pencil of Mr. Keffer committed to paper.

ORGANIZATION.

The Horticultural School at Ghent is one of two national schools supported by the Belgian Government. It is a department of the Ghent University, though entirely separate in its management and course of study.

The board of instruction comprises seven officers, including the director, who is also a professor in the University. The range of instruction may be gathered from the following departments, to which are appended the names of the professors who conduct them:

1. Director, Professor Kicks.
2. Vegetable and arboriculture, Professor Burrenich.
3. Garden architecture, Professor Pynaerd.
4. Language (French, Flemish, German, and English), Professor Rodigas.
5. Theory of horticulture, Professor Van Hulle.
6. Chemistry, Dr. Vobele.
7. Plant drawing, Dr. Pannemaker.

The course of study extends through three years, and the list of theoretical studies, when compared with the practical horticultural drill, shows that the school is more elementary in its character than the Horticultural School at Geisenheim; at the same time the manual skill attained by the pupils is of the first order.

The syllabus of studies stands as follows:

Studies.	Hours per week.	Years.
Plant drawing	2	3
Garden architecture	2	3
Vegetable culture	1	3
Arboriculture	1	3
Theory of horticulture	2	3
Botany	1	3
Physical geography	1	2
Chemistry	1	2
Arithmetic	1	1
Physics	1	1
English language	1	1
German language	1	1
French language	6	3
Flemish language	6	3

CONDITIONS OF ENTRANCE.

Students are admitted on the following terms: They must be at least fifteen years old, must pass examinations in geography and arithmetic, and understand sufficient French to receive instruction in that language—this last requirement excludes the sons of the common people, who speak only Flemish. I may add that French is spoken in Belgium only by the higher classes, and that in the high schools and universities it is used exclusively.

The number of students is limited to 25, and there are now 23 in attendance. Tuition is free, the expenses of maintaining the school being paid by the Government, which gives to students whose parents are in straightened circumstances a gratuity of from 200 to 400 francs per annum.

GOVERNMENT.

The government is rigid. The students are required to show all outward signs of respect to their superiors, to attend lectures punctually, to refrain from all conspiracies among themselves, and to keep aloof from public places of amusement; they are forbidden to use alcoholic liquors, to receive packages from home, to take flowers, plants, or fruits; to play games of chance, or to handle books or instruments without the permission of the professor in charge.

Each student has his own desk and box for implements, which he must keep in good order; he has his number in class for the year, and any unexcused absence, either from class or practical work, is punished by extra labor. The director reports the progress and deportment of students to their parents or guardians once in three months. No pupil can be expelled without the permission of the Government minister of the interior.

The students, when graduated, are employed in the gardens of noblemen and prominent citizens, and often have the management of public parks and grounds.

In this school floriculture is made prominent, receiving the principal attention both in instruction and practice. As a consequence botany is more extensively and thoroughly taught than the other natural sciences.

BOTANY.

The lectures on botany extend through the entire course. The students are thoroughly drilled in systematic and structural botany, with a special application of the science to practical horticultural work, and are required to make herbariums of native plants, though no specific number of specimens is demanded.

The apparatus for instruction is very extensive, consisting of—

1. The great collections of plants in the conservatories.

2. An herbarium of thirty thousand specimens, comprising the entire flora of Belgium and a large number of the representative plants of other parts of Europe and of America. The plants, numbered to correspond with their names in the catalogue, lie loose in folds of straw-paper, which are placed in covers of tar board and tied with broad bands of tape. These cases, each with the name of its order printed on the shelf on which it stands, are inclosed with glass doors.

3. A collection of casts showing the structure and habits of growth of the lower orders of plant life, the different tissues of the Phaneragamia, the parts of flowers and fruit, &c.

4. A large number of charts covering the same subjects as the casts.

5. Six new Hardtnack microscopes, for the use of students, which are supplied with three eye pieces, three objectives, a good light-concentrator, scalpels, needles, and other apparatus. They were obtained in Paris, the price paid being 250 francs ($48) each. The microscopical laboratory is fitted up with tables for fifteen students arranged parallel to the window, the whole south side of the room being glass.

HORTICULTURE.

In theoretical horticulture the students listen to one lecture a week throughout the course. A review of their notes occurs every Saturday, and any errors are then corrected by the professor in charge. All the students work every afternoon, Saturdays included, in summer six and in winter three hours a day. During work they are under the supervision of a foreman who directs and explains the operations performed; any disobedience to his orders is punished by extra hours of labor.

Under the system arranged the course in labor is made to correspond to the course of instruction, so that every fact gained theoretically in the lecture room is reduced at once to practice in the garden. The work, which in the first year is confined to the heavier and more common operations, is changed to a higher order in the second, and in the third comprises those processes only which require artistic skill.

During the summer season the senior class, in charge of Professor Van Hulle, make excursions to places noted for the successful man-

agement of certain classes of plants, both in Belgium and the adjacent countries. Last summer they visited, among other localities, Messange Place, near Marsche, Belgium, to investigate the method of cultivating orchids in practice there.

THE PROPAGATING HOUSE.

The propagating house, 60 by 9 feet, is built against a high stone wall, which runs east and west. The roof has a southern slant and sharp pitch, the front wall being only 4 feet high and made of brick. There are two rooms of equal size, one for the growth of grafted and budded stock, the other for the propagation of flowers from cuttings. The benches are $3\frac{1}{2}$ feet wide, with a path 2 feet broad running between them; they are filled first with a layer of gravel, then 2 or 3 inches of sifted coal ashes in which the cuttings are planted. Ashes are said to be entirely free from fungus growths, though not so good a retainer of moisture as sand; to obviate this difficulty, and to insure more even-temperature and moisture, the benches are divided into compartments 6 feet in length, each of which has a glass covering. There were cuttings of lobelia in one case, alternanthera in another, in a third some recently potted acharanthi, all looking healthy and strong.

The house, as are all the conservatories, is heated by hot water-pipes, which run under the benches; these are boarded to the floor, the bottom heat being regulated by doors in the partition.

Only the more tender plants are rooted in the propagating house; geraniums are propagated in hot-beds in the spring, and when rooted, are planted at once in the flower borders. Roses are grown from cuttings, in beds in the open air, in much the same way that we root currants.

For soil for flowering plants they use a mixture of peat, leaf loam, and sand, giving a strong and rather heavy soil for the coarser feeders and a light sandy loam for the more delicate ones.

Much attention has been given the subject of manures for flower culture. In preparing beds for such plants as roses, gluxinias, grosularias, and other strong growers, the soil is enriched with decayed dung-earth, a compost of cow and horse manures only, which has been mixed and turned until of even consistency throughout. For pot culture this decayed compost mixed with leaf loam is the best thing, Professor Van Hulle informs me, that can be used. Liquid manure is found to be the best fertilizer for open air cultivation. It is prepared in the barns. A cemented vat is made and partly filled with water, into which all the excrements, both solid and liquid, are put. Every three weeks the vat is emptied, the contents being diluted with water and poured upon the flower beds. Professor Van Hulle considers this better than any commercial fertilizer made.

BULB CULTURE.

The forcing system here is employed in bulb culture with great success, and as the same process is followed at the Frankfort Palme Garden, Geisenheim, and other places I have visited, I will describe it in detail. The bulbs are planted in 4-inch pots about September 1, and placed in a cool, dark cellar, where they are covered with 3 inches of earth. When the tops are about half an inch high the plants are taken to a greenhouse, and each one is covered with a pot to exclude the light; they are left there fourteen days, receiving little water and no bottom heat, at the end of which time they are uncovered, allowed full sunlight, watered freely, and given a bottom heat of 15° R. (66° F.), gradually increased during five or six days to 25° R. (88° F.) or more. The bulbs thus treated give large flowers in trusses of remarkable size.

THE CONSERVATORIES.

The Ghent horticultural school has conservatories that are unusually extensive and very valuable as aids to instruction. Before the school was located in its present grounds the property was used as a public botanical garden, and it was during that time that the immense collections were made.

There is one main conservatory, about 250 by 60 feet, which has a central octagon-shaped room 80 feet in diameter and 40 feet high, two long corridors on each side of this room occupied with tropical trees and shrubs, and a wing at each end fitted up as a lecture room. On both sides of the high corridors mentioned there are lower rooms with roofs, which curve to the ground, in which an extensive collection of miscellaneous plants is grown. The octagon room is well filled with large and beautiful palms, comprehending every known species. I noticed particularly an immense sago tree that had reached the roof and seemed vainly trying to force its way through.

In the rooms devoted to tropical plants there are some magnificent specimens of the acacia, vanilla, coffee, and clove trees. All the plants are of good size and seemed strong, but they are not in first rate condition. Professor Van Hulle informs me that the heating apparatus is defective and they have not help enough in the care of the houses to keep them in the best shape.

The cold house contains plants which, requiring lower temperature, are thriftier than those in the tropical collection. This large structure (200 by 30 feet) has only one glass side, through which sufficient light is admitted to supply the needs of the resting plants. There are here some very fine specimens of auricaria, eucalyptus, myrtle, lauristinus, and camellia, and many old ferns, one of which, of the "stag horn" variety, is 3 feet high and as many in diameter.

Going from this to the orchid house I found a good collection of or-

chids, pitcher plants, and aquatic plants, the latter occupying a large vat filled with water, on whose surface lay the immense leaves.

This whole vast plant collection is employed in teaching—an apparatus whose equal can hardly be found in Europe. The great difference of treatment required by the various plants, their names, habits, native homes, diseases, structure and properties are all clearly and thoroughly taught, the collection affording everything needed in the way of illustration.

I noticed, surrounding one of the curved roofs of the conservatory, an immense grape "cordon horizontal." It consisted of two vines, one very much the larger, grafted into each other at their extremities. The cordon extended along the lower part of the roof, about 18 inches from the ground, up one end, along the top to the other end, then down and to the place of beginning. The total length is not less than 175 feet, the larger vine being at least 100 feet long, 4 inches in diameter at the ground, and 1 inch at the end of the branches. The fruit spurs, which are cut to four eyes, starting from the main cane or short branches, occur at regular intervals of 2 feet. I was assured that the vine is a profuse bearer and the fruit of good quality; certainly it serves an excellent purpose as an ornament.

VAN HOUTTE'S COMMERCIAL HORTICULTURAL ESTABLISHMENT.

We visited the grounds of Louis Van Houtte, at the instance of Mr. Lefevre, the United States vice-consul at Ghent. This firm, while doing a heavy business in nursery stock and seeds, makes a specialty of hot-house plants and bulbs. Particular attention is given the origination and propagation of new varieties of flowers, and it was this subject which we investigated.

Soil for pot culture.—Everything considered, oak-leaf mold is found to be the best foundation for soil for pot culture; with this is mixed short manures, clay, sand, &c., as may be best for the particular plant. As an instance, for forcing hyacinths they mix a great deal of cow manure and sand with the leaf mold. This makes a very rich, light soil.

No commercial fertilizers are used. After trying everything of the kind that has been offered, Mr. Van Houtte assures us that he has found nothing so good as the animal manures.

Roses.—New varieties are obtained principally by crossing, though some good sorts have come from sports. In growing roses, cuttings are generally taken in July and August and planted in sand, under which is a foundation of leaf mold. The beds are covered with white-washed glass. Cuttings are made of half matured wood, and are grown without bottom heat.

For pot culture of roses they make a soil, using leaf mold as a basis, and with this mixing clay and well rotted horse manure. Care is taken

that too much clay should not be added so as to make the soil hard, its purpose being simply to strengthen the compound. For out of door culture a clay soil heavily manured with horse dung is best.

Mr. Van Houtte is a very extensive grower of camellias, azaleas, and rhododendrons; the greater number of the fifty hot-houses being occupied by these three classes.

Camellias.—The camellias are all grafted. Seedlings of the wild single-flowering variety (*C. japonica*) are grown, and on these are grafted the fine sorts. Most new camellias are sports on old plants; for instance, they had here a white camellia, and it threw out a branch which produced flowers edged with pink. The latter blossom was a sport, and the branch on which it grew was cut off and grafted on a wild stock, and thus became the basis of a new variety. No crossing of camellias is carried on here, but in Italy, where these plants are extensively grown in the open air, many fine new varieties are obtained by crossing. There are three thousand established varieties of camellia.

Azaleas.—Here again seedlings of the wild variety (*A. indica*) are used as stocks, and only the best kinds are grafted upon them. They employ the common whip graft and wrap with light cotton thread, no wax or other covering being necessary. The wood of both stock and graft is immature, the young shoots being used. The grafts are placed in a glass-covered case in a greenhouse, in a slanting position, so that the water will not stand on the graft and rot it. They are given a gentle bottom heat, the glass covering insuring even temperature and moisture. They are watered very little at first and moderately at all times.

Insect pests.—This firm has tried many things for the destruction of the insects that infest hot-house plants, particularly the shield louse and red spider. Mr. Van Houtte informed us that their most successful way of killing these pests is to wash the plants with a solution made by putting equal weights of tobacco stems and brown bar kitchen soap in water. The mixture is left to stand twenty-four hours and is stirred thoroughly before using. It is applied to leaves and branches with a brush, and is very effective, without damaging the plants.

Palms.—There are several houses devoted to the growing of palm trees. The seeds are planted, in sandy loam, in pots, and receive just about such care as we give geraniums; repotted when needed and watered when dry. The palms are not considered hard to manage and certainly the great number of plants, large and small, all uniformly in perfect health, tended either to prove the assertion or, at any rate, to show excellent care.

Bulbs.—The best soil for out-of-door culture is a light, sandy, dry loam, which has been heavily manured with well-rotted cow-dung. They require perfect drainage, so that at no time the ground is very wet. All bulbs, except lilies, should be taken up every year as soon as the tops have withered. There is an excellent plan for wintering

bulbs here. They are lifted during dry weather and the dirt shaken from them; the tops are cut back, but the roots are allowed to remain. The bulbs thus prepared are placed on shelves in a room of low temperature, but they are never allowed to freeze. They lie one layer deep on the shelves, the air circulating freely among them, and they are left wholly without covering. Half hardy bulbs are kept in the bulb-house in pots during the winter.

The origination of new varieties of bulbs.—As the processes for the different species is much the same, I will only describe that for getting new hyacinths. Some new varieties are obtained from sports, but by far the greater number are from seedlings by crossing two old varieties. The process is as follows: When the flower of the mother plant is almost ready to open the pollen is removed by cutting out the anthers. It is then allowed to come to maturity. When fully blown, pollen from the male plant is applied to the stigma of the female, either with a fine camel's hair brush, and this is the better way, or by the fingers. This operation must be performed in bright sunshine during dry weather. The plant thus fertilized must be kept free from rain until the seed is set; an umbrella-like covering is here used to protect it. It must also be completely isolated from other hyacinths, so that no other pollen can reach it. Both plants are always grown in the open air, as they are more apt, in this way, to be strong and in a naturally healthy condition. The seed resulting from the cross is planted, and when the bulb produces flowers its value is determined. It generally takes ten years to get three bulbs of a new variety, and at least twenty-five years before sufficient bulbs are obtained to begin their sale.

The orchid houses are very extensive, and a great many novelties are grown. The pot-grown orchids are planted in a mixture of charcoal and broken pottery, and the tops around the plants are covered with growing sphagnum. The orchids are syringed twice a day in winter, and from three to five times in summer. Every evening the houses are densely filled with steam. During the winter the temperature is kept at from 65° to 80°, averaging 70° F.

The houses and their arrangement.—Most of the houses are long, varying from 60 to 220 feet, and they are from 12 to 20 feet wide. They are all built above ground, the side walls bricked as high as the benches and having glass ends and roof, with the sides above the benches also of glass. All the houses are low, and when there is a central bench it is either elevated or contains tall plants; the fact that the plants do best nearest the glass not being lost sight of. The houses are all heated by hot-water pipes, which radiate from a central heating house, and so arranged as to keep a current of hot water passing through the pipes constantly. In none of the houses is sand used on the benches; sifted coal ashes having been found to be better, and the refuse of tanneries the best thing for this purpose. The latter is said to be equal to ashes

in its freedom from fungus growths, and superior as a conductor of heat and a retainer of moisture.

In passing through the houses of this firm we were struck with the universal healthiness of the plants; not a single really poor specimen did we see, and most of them were very thrifty and strong.

In one of the orchid houses there is a large collection of pitcher plants, among them some of great rarity. We were shown one with dark green foliage, each leaf terminating in a tendril which supported a large reddish-brown "pitcher," the lid of which stood rigidly upright. It was valued at $250.

In one of the "New Zealand" houses there is a magnificent collection of acacias and allosias; the odd forms of the acacia leaves contrasting strangely with the fine frond-like leaves of the other.

There is a large circular-shaped house devoted to specimen palms, bananas, and tree ferns. The plants are from 5 to 15 feet high; not remarkably large, but in excellent condition. All are fresh and clean, no decaying or sickly leaves being seen.

DOWNTON COLLEGE OF AGRICULTURE.

The College of Agriculture at Downton, near Salisbury, was established in 1880 for the purpose of preparing students for positions as landowners, surveyors, and farmers.

The faculty numbers, beside the principal, five professors, occupying the chairs of dairy farming, chemistry, natural history, estate management, and veterinary medicines. Professor Wrightson has charge of the agricultural department, in addition to the duties of general executive.

The government of the college is vested in a council, composed of the president and the several professors.

As a condition of admission, students are required to have entered their eighteenth year, and to furnish satisfactory references as to character. There are no entrance examinations, the principal deciding upon the fitness of the applicant for admission.

Expenses, including board, lodging, laundry, and tuition, but exclusive of books, apparatus, breakage, laboratory fees, &c., £129 per year. For students boarding outside the college, £60, both payable in equal installments at the beginning of each term.

Instruction is given by lectures, field classes, and practical work. The student's progress is tested by weekly examinations, the results of which are entered upon the record. Each student is required to keep a journal of all the operations of the farm, which is examined at regular intervals by the professor in charge. An inventory of all stock, fixtures, and improvements is taken once a year, when all students are required to be present.

The farm, which comprises 550 acres, is admirably adapted for purposes of instruction on account of its great diversity of soils and products. The rotation of crops is so planned as to provide for growing 200 acres of grain, and for keeping a flock of sheep, numbering 700 ewes, of the Hampshire Down breed.

The museum and library, owing to the recent organization of the institution, are yet in a formative state, though the latter contains a number of standard agricultural and scientific works, and many periodicals on these subjects.

The chemical and physiological laboratories are furnished with the newest apparatus, the one for the study of analytical and agricultural chemistry and the other for botanical and zoological investigation.

Student labor.—Students are required to work in the fields and to help in the management of the live stock. By special arrangement with the professor of agriculture, they may take any regular detail, such as that of dairyman, pig man, shepherd, &c.; they are also encouraged to assist the professors in experiments on the values of manures and feeding stuffs, and in other investigations of interest to the farmer. They receive no compensation for such services.

SYLLABUS OF SUBJECTS.

The following syllabus of subjects, selected from samples furnished, will give a definite notion of the range and character of the instruction given in this institution.

AGRICULTURE.

Soils.—1. Origin; geological distribution; classification; proportions of sand, clay, lime, vegetable matter, mineral fragments; effects of tillage; subsoil; influence of climate, aspect, altitude, slope, color, and texture upon fertility; land drainage; claying, clay burning; paring and burning, marling, chalking, warping, and mixing; plowing, harrowing, rolling, cultivating; effects of fallowing pulverization by frost.

2. General and special manures; adaptation of manures to crops; conditions which influence the quality of farm-yard manure; treatment and aftertreatment of the same, application; composts; sea-ware; green-crop manuring; bones; superphosphates; potash; salts; gypsum; guano; sulphate of ammonia; soot; nitrate of soda; refuse cakes; blood manure.

3. Implements: Plows, harrows, cultivators, and other tillage instruments; drills, seed barrows, and other sowing implements; hay tedders, horse-rakes, carts. and wagons; harvesters, reapers, and mowers; barn implements, thrashing and dressing machines; chaff cutters, root pulpers, and turnip cutters; steam plows and cultivators.

Crops.—1. Rotations; fallowing; root, forage, cereal, and other ordinary farm crops; their history, botanical position, varieties, soils suitable for; preparation of the ground; times and methods of sowing; kind

and quantity of manure; seed; after cultivation; harvesting, consumption, or preparation for market; cost of production; probable yield; insect attacks; diseases.

2. Cultivation of potatoes, raising of new varieties; marketable vegetables adapted for field cultivation.

3. Laying land down to grass; water meadows.

Live stock.—1. Agricultural horses: breeds, general management, feeding, number required, cost of maintaining, capital sunk in.

2. Sheep: breeds; management of ewe flock, management of lambs; winter feeding, shed feeding; relations of food to increase; wool: Dipping, salving, and smearing; number of sheep maintained per acre; diseases (foot rot, fluke, fly, &c.).

3. Cattle: Short-horns, Herefords, Devons, Long-horns, Ayrshires, Polled Galloways, Polled Angus, and other breeds; rearing and fattening of calves; summer and winter management of store stock; the fattening process; pedigree.

4. Swine: Breeds, management, fattening, bacon curing. Farm buildings, general design, construction, and cost; fences; capital; labor; task work.

Dairy farming.—Breeds of dairy cattle; soils, climates, and crops suitable for dairying; breeding, feeding, and treatment of dairy stock; milking; rearing of calves; management of young stock; cheese making; butter making; amount of produce per cow; influence of food on quality and quantity of produce; dairy utensils; the commerce of the dairy; American and Canadian dairy farming; suburban dairy farming.

Cheese and butter making: butter making is carried on all through the year in the college dairy, and cheese making during a portion of the summer session.

Poultry.—Breeds for laying and for table; the sitting hen; management of young chickens; fattening of fowls; capons; fowl-houses; feeding and general management; cost and produce; artificial incubation.

The agricultural instruction is imparted in the form of lectures, field classes, excursions, attendance at sales and markets, and practical work on the farm, in the barns, and in the dairy.

ESTATE MANAGEMENT AND LAND AGENCY.

This important subject forms a branch of its own, and is not left to the joint efforts of the professional staff. The lectures and field classes embrace the following subjects: Leases and agreements; the drawing up of legal forms and schedules; valuation between outgoing and incoming tenants; valuation of landed and house property; the law of landlord and tentant; life estates; freehold; copy-hold; enfranchisement of copy-holds; uses and principles of valuation tables; law of fixtures; dilapidations; building and repairs; measurement of brick and other work; brick making; materials used for building; geology

as it relates to material; pond and tank making and general water supply; tithe-rent charge; rates, taxes, &c., as they relate to property.

FORESTRY.

The history, propagation, uses, treatment, and value of timber trees. Management and valuation of underwood; the planting, thinning, and general management of fir plantations; measurement of standing and felled timber and of converted timber; use of sliding scale; sale of timber and underwood; the economy of woods and forests in the management of estates.

The lectures are supplemented by practical classes in the neighboring woods.

MENSURATION AND LAND SURVEYS.

Measurement of surfaces; quantity of land cultivated by various implements; areas occupied by crops; mensuration of solids and estimates of the contents of tanks, ditches, wells, manure heaps, walls, ricks, stacks, timber, road metal, cuttings, and embankments.

Field and road surveying; plotting and drawing of plans and determination of areas surveyed; leveling and plotting of levels; use of prismatic compass, quadrant, &c.; details of the chain, theodolite, and leveling staff; mode of keeping surveying and leveling books; the ordnance survey, ordnance maps and bench marks.

BOOK-KEEPING.

The uses of the day-book, cash-book, journal, and ledger; journalizing; opening and closing accounts in the ledger; profit and loss and balance accounts; taking stock; valuation; partnerships.

COMMERCIAL KNOWLEDGE.

Monetary transactions of all kinds; banking; buying and selling stock; bank notes; bills receivable and payable; promissory notes; drafts; interest; discount; commission; stamps; technical terms in use in the various markets; modes of trading in various commodities in different districts; prices current of cattle, sheep, and pigs; British and foreign corn, seeds, hops, hay and straw, potatoes, fertilizers, feeding stuffs, hides and skins, wool, butter and cheese, fruits and vegetables.

PHYSICS AND MECHANICS.

Barometer, thermometer, rain gauge, and other instruments employed in meteorology; levers and their combinations; laws of motion; steam engine; agricultural machinery. The steam-engine, grinding mill, thrashing machine, reaper, mower, elevator, plows, &c., on the farm, are periodically taken apart for cleaning, and the students are then exercised in naming the various parts, explaining their action, and restoring them to their proper positions.

CHEMISTRY.

Inorganic chemistry.—Elements and compounds; symbols and formulæ; equations; weights and volumes; the metric system; correction of gaseous volumes for temperature and pressure; thermometric scales; chemical calculations. Chemistry of the non-metallic elements and their principal compounds: Hydrogen, oxygen, nitrogen, the atmosphere, water, carbon, carbonic acid, ammonia, nitric acid, chlorine, hydrochloric acid, phosphorus, phosphoric acid, sulphur, sulphurous and sulphuric acids, silicon, silicates, bromine, iodine, fluorine, boron. Chemistry of the more important metallic compounds: The alkali metals and their chlorides, nitrates and sulphates; chloride, nitrate, and sulphate of ammonium; calcium, lime, carbonate, phosphate, and superphosphate of lime; magnesium, iron, aluminum, copper, and lead.

Organic chemistry.—Determination of carbon and hydrogen; constitutional formulæ; classification of organic compounds; cyanogen, prussic acid, cyanides, and ferrocyanides. Hydrocarbons: Marshgas, ethylene, benzine, anthracene. Derivatives of the hydrocarbons: Wood spirit, formic acid; common alcohol, fermentation, brewing and distilling, acetic acid, vinegar making, acetates, fruit essences; oxalic acid; glycerine, oils and fats, saponification and soap manufacture; tartaric acid, cream of tartar; rochelle salt; citric, lactic, malic, succinic acids; grape sugar, cane sugar, starch, dextrine, and cellulose; glucosides; carbolic acid, benzoic acid, aniline, salicylic acid, and aldehyde, coumarien, and vanillin; madder and artificial alizarine, indigo, tannin, gallic acid, pyrogallol; urea and uric acid; alkaloids; albumen, casein, gelatin, and allied bodies.

Agricultural chemistry.—The relation of the science of chemistry to the art of agriculture; food of plants; chemistry of germination; the atmosphere, meteoric water, and soil as sources of plant-food; physical and chemical properties of soils; the skeleton or frame-work of soils and the "fine earth" they contain; drainage-waters; analysis of soils; chemical changes in the plant and in the soil during growth of crops; rotation of crops; manures, special and general; farm-yard manure; nature, analysis, and adulterations of guanos, superphosphates, and other manures; constituents and utilization of sewage; composition of different crops and effect of manures thereon; composition of feeding-stuffs, their manurial value; foods required for horses, oxen, sheep, and pigs, respectively; dietetics; ratio of flesh-formers to heat-givers in the staple feeding-stuffs; the chemistry of milk and dairy products.

Laboratory course.—Chemical manipulation; preparation of reagents; experiments with gases; preparation of chemical compounds; chemical testing; qualitative analyses; reactions of the metals and acids, simple salts, mixtures of salts, organic acids, alkaloids; quantitative analysis; determination of the principal acids and bases; examination of commercial salts, manures, waters, feeding-stuffs, soils, organic compounds.

GEOLOGY AND MINERALOGY.

Forces modifying the earth's surface: igneous, aqueous, and metamorphic rocks; rock-forming minerals; the stratified rocks of the British Isles, their structure, composition, distribution, economic products, and organic remains; soils, their origin, properties, and relation to the underlying formations: mineral fertilizers, metallic ores, fuel, and building materials: springs, water supply, and drainage.

Practical course.—The examination and identification in the laboratory of minerals, rocks, soils, and fossils; geological surveying and field-work.

BOTANY AND VEGETABLE PHYSIOLOGY.

The external conformation of plants; classification; structure and functions of the tissues; chemical composition; plant-food, its sources and nature; vital processes in the plant; hybridization and the production of new varieties: a particular knowledge of agricultural plants, especially of grasses, cereals, and clovers; identification of seeds of weeds in samples; determination of germinating power of seeds. Fungal diseases. Rust, bunt, smut, mildew, ergot, potato disease; diseases due to animal pests; malformations.

Practical course.—Two early morning excursions each week during the summer into the surrounding country (the Hampshire Downs, Avon Valley, and New Forest); dissection, description, and identification of flowering and flowerless plants in the physiological laboratory.

ZOOLOGY.

Distinctive characters of the classes of animals; a more detailed knowledge of the mammals, birds, insects, worms and parasites; peculiarities of the vole, hedgehog, mouse, rat, mole, cat, dog, rabbit, sheep, pig, ox, and horse; of the frugivorous and insectivorous birds and birds of prey: of crop-destroying insects, such as the wire-worm and turnip fly; of the earth-worm, slug, and snail; and of the fluke, bots, and other animal parasites. Instruction in this subject is given by means of lectures, field classes, and practical work in the physiological laboratory.

ANATOMY AND PHYSIOLOGY.

The position, structure, and functions of the organs of circulation, respiration, digestion, secretion, and reproduction in the horse, ox, sheep, pig, dog, cat, and rabbit; the nervous system and the sense organs; muscles, bones, joints; dentition, its application in determination of age; inute structure of the tissues; blood, its organic and chemical constitution; food, the quantities and kinds necessary to balance the losses in the animal body; the several processes which it undergoes during digestion; production and regulation of animal heat.

The students are taught anatomy by being required to perform in the physiological laboratory the actual dissection of specimens or parts of specimens of the above-mentioned animals, the result of each dissection being sketched in an appropriate book, and all the parts named to the satisfaction of the professor. The osteological studies are also conducted in the laboratory, the students being required to familiarize themselves with the names and positions of the bones of the foregoing animals, skeletons of which have been prepared at the college.

VETERINARY MEDICINE AND SURGERY.

The horse, ox, sheep, pig, and dog, in health and disease; accidents and operations; principles and practice of shoeing; parasitic affections; properties, doses, and modes of administration of the usual therapeutic agents; stable management; hygiene; breeding, parturition, and gestation; diseases connected therewith; hereditary influence; morbid anatomy; demonstrations.

THE ROYAL AGRICULTURAL COLLEGE AT CIRENCESTER, ENGLAND.

Accompanied by my secretary, Mr. C. A. Keffer, I left London on the morning of February 8, and reached the Royal Agricultural College, near Cirencester, Gloucestershire, at 2 p. m. on the same day. We were conducted at once by the porter to the office of the principal, Rev. J. B. M'Clellan, A. M., to whom I had previously written, informing him of the object of my visit. He received us with the proverbial courtesy of a cultured Englishman, and declared that himself and all his faculty would be at my service to furnish the information I had come to seek.

The members of his faculty, whom I met soon afterwards, are able and scholarly gentlemen, to whose kind attentions the fullness of this report is mainly due.

THE MUSEUM.

Under the guidance of Professors Kinch and Harker we left the office of the principal to inspect, first, in order, the museum, which contains a large variety of specimens designed for instruction in agriculture. The hall they occupy is about 30 by 60 feet, and the arrangement of the different collections is well adapted to study. In other words, it is, as one of the professors remarked, "a museum for work instead of scientific display." A brief description of the various groups of illustrative objects will show its practical character.

Among the substances gathered for chemical analysis are a hundred different commercial fertilizers held in vials, various forage cakes, including kinds made from seeds of hemp, rape, palm, cocoanut, cotton, and flax; a selection of sugars, starches, animal and vegetable oils, and mineral phosphates.

Further on is a series of excellent wax models representing the English root crops, such as mangels, swedes, turnips, and potatoes; some of these are of remarkable size. Next in order, fastened against the wall, are neatly-preserved samples of a hundred British grasses and also a display of fine cereals.

Veterinary collections.—About one-fourth of the entire museum is taken up with the veterinary collections, many of which show extreme care and skill in their preparation. A large case contained the whole catalogue of veterinary surgical instruments, and occupying the center of the west end are skeletons of a horse, cow, sheep, pig, dog, cat, and rabbit. A similar case incloses the entire list of animal organs, showing abnormal or diseased conditions preserved in alcohol. Near at hand, hanging upon the wall, I noticed numerous samples of horseshoes, among which are many novel patterns, never dreamed of except in England. The pathological group embraces many papier-maché models for teaching the anatomy of the domestic animals; these include delicately formed organs, such as the eye, lung, liver, heart, &c., representing both normal and abnormal states.

But the most remarkable anatomical collection consists of nearly two hundred papier maché and natural specimens of animal jaws, illustrating the teeth in all stages of their growth. The dental formation from the fœtus to the mature animal is fully illustrated in the horse, the cow, and the sheep. The teeth of the pig, dog, and cat are also included. but not so fully. This novel and beautiful apparatus for teaching animal dentition is said to be the best in all England.

The geological collection, though not complete, comprises many well selected fossils which characterize the geological formations of England, and three thousand specimens of British plants constitute the college herbarium. The entomological department, though somewhat limited, includes all the harmful insects of the country in which it is gathered, and a series of drawings which show the character of their depredations.

On the whole the museum, though not striking as a scientific exhibit, is admirably adapted to the purposes of instruction in an agricultural college.

THE LABORATORIES.

From the museum we were conducted by Professor Harker to the botanical laboratory and lecture-room. This consisted of the laboratory proper, in which the biological collections are kept, and the lecture-room where class instruction is given. The first is an ample apartment, containing, among other apparatus, four hundred large, well-executed drawings illustrating zoological and botanical anatomy; some of these are in water colors and others in crayon. Arranged on convenient tables stand nine Beck microscopes, with 1-inch and ¼-inch objectives

attached by nose-pieces. There is also an excellent section cutter for the use of students.

Botanical garden.—An interesting adjunct of the biological department, and contributing to its resources for instruction, is the botanical garden, lying behind the main building, and occupying 1½ acres. This garden is laid out in numerous plats, each of which is occupied by representatives of closely-allied species, including specially a full list of the grasses and other economic plants.

In the lecture-room, which is used both for chemistry and botany, and is seated for 135 students, we found also a series of samples of wheat plants with the roots and heads perfectly preserved, the result of an experiment by Sir J. B. Lawes, LL. D., at Rothemsted, Herts, to test the effect of different manures. A single variety of wheat had been grown upon the same soil for nineteen successive harvests. The ground, in this interesting series of experiments, was divided into small plots, in one of which the nineteen successive wheat crops were raised without manure, while in each of the others a definite weight of a specified fertilizer was applied every year throughout the series. In this way, by nineteen repeated applications, the exact effect of every kind of manure, whether stable or commercial, was determined. These twenty eight samples of wheat, therefore, present the most interesting object-lesson in the world, the unmanured specimen showing about half the size and weight of the best manured. Of the twenty-seven manures under experiment, the size of the wheat plant proved that superphosphate, ammonia salts, and magnesia salts were the best in the order I have named them.

Department of physics.—The department of physics occupies convenient apartments over the biological laboratory and lecture-room. The laboratory is well furnished with apparatus for illustrating the various topics of mechanics, light, heat, electricity, &c. Professor Ohan is enabled to illustrate his lectures on the steam engine with excellent working models, made in section, so that the workings of every part, both internal and external, may be clearly seen. It is evident from the number of model engines, pumps, water wheels, and other mechanical appliances that physics is here taught in its practical relations to agriculture.

Chemical laboratory.—The chemical laboratory, which we inspected next in order, comprises four spacious apartments, of which the first is the office of the professor in charge, containing the chemical library, substances for analysis, &c.; the second is the scale-room, wherein are eight balances manufactured by L. Oertling, London; the third is the general laboratory, in which the students have their practice in qualitative and quantitative analysis. This room is furnished with thirty-six tables, each supplied with twenty reagents and all other necessary apparatus. The instructive work in this laboratory extends through the

first five terms of the course, the remaining two being spent in the fourth room, which is used wholly for the analyses of substances connected with agriculture. These analyses are made by the professor, assisted by the senior students, who in this way become experts in agricultural chemistry. I noticed several young men busily engaged in finding the constituents of some product of the farm under the direction of two assistants.

I cannot withhold my hearty commendation of the completeness of equipment in this laboratory and the perfect neatness and system which is manifest throughout.

Work of the laboratory.—The original researches made here by the officers and the students under their charge comprise analyses of soils, fertilizers, and all the products of the farm. At the hazard of repeating what is already given in the course of instruction, I will mention here the most prominent of these, which are either now in progress or have been made recently:

1. An examination of the physical and chemical properties of several typical English soils, their absorptive powers, &c.
2. On the uses in agriculture of basic slag from the Gilchrist-Thomas process of steel manufacture.
3. On the constituents of the varieties of sorghum.
4. On various coloring matters in plants (belladonna, &c.).
5. On the water used for drinking and domestic purposes in the town of Cirencester.
6. On the constituents of the various manures and the plants they are used to fertilize.
7. On the soy bean (*Soja hispida*), its chemical composition and value as a food.

The following is a detailed account of Prof. Edward Kinch's description and analyses of the soy bean of China. I append his entire report of the results of this interesting investigation, because it not only shows the character of the work done in his laboratory, but indicates that this bean may be profitably grown in some parts of the Western States. Indeed, the same bean was grown on the experimental grounds of the Iowa Agricultural College last year, and showed a very large yield:

THE SOY BEAN.

This bean, sometimes known as the Japan pea and China bean, is the seed of the *Soja hispida*, Miquel (*Glycine hispida*, Moench; *Dolichos Soja*, Linné; *Glycine Soja*, Jaquin) a plant of the natural order Leguminosæ, suborder Papilionaceæ, and tribe Phaseolæ. Its natural habitat appears to be China and Japan; it also grows in Mongolia and in India, in the Himalayas, and within the last few years it has been cultivated experimentally in several European countries. This bean is worth more than a passing notice, as it is the vegetable which approaches most nearly in its proximate chemical composition to animal food. This will be seen later on.

There are a great number of varieties of the soy bean known, which differ to some extent in the shape, size, and especially in the color of the seed, and in a few minor

particulars, but which seem to vary comparatively little in chemical composition. Dr. C. O. Harz has classified the principal varieties as follows:

GROUP I.—*S. hispida platycarpa.*

1. *olivacea.*
2. *punctata.*
3. *melanosperma.*
   - *a. vulgans.*
   - *b. nigra.*
   - *c. renisperma.*
   - *d. rubro-cincta.*
4. *platysperma.*
5. *parvula.*

GROUP II.—*S. hispida tumida.*

6. *pallida* (Roxburgh).
7. *castanea.*
8. *atrosperma.*

These names sufficiently indicate the nature of the variety as far as the seed is concerned.

The soy bean is extensively cultivated in the north of China, whence it is exported to the southern provinces; it is here pressed for the sake of its oil and the residual cake largely used as a food for man and beast, and also as a manure.

In Japan it is known by names signifying the bean, and from it are made not only soy but a paste known as *miso*, which is in constant request at nearly every meal, *tofu*, or bean cheese, and other foods used to a less extent. This bean cheese is also well known in China, and is obtained by extracting the legumin from the beans with water and precipitating it with brine. An analysis of it is given below.

These foods are most valuable additions to the dietary of the Oriental nations, and especially of the Japanese, who use so little animal food; they tend to supply the deficiencies of the staple food, rice, in nitrogenous matter, fat, and also in mineral constituents.

The Buddhist priests, who are strictly forbidden to use animal food, consume considerable quantities of these beans, principally in the form of *miso*.

The soy bean first attracted attention in Europe in 1873, when specimens from Japan, from China, and from India were shown at the Vienna International Exhibition. Dr. Forbes Watson, reporter on the products of India, called attention to it in the Catalogue of the Exhibits of the Indian Museum. Since then numerous experiments have been made on the European Continent on its growth, and also feeding experiments with the bean and its straw on different kinds of domestic animals have been prosecuted. Such experiments have been carried on by Wolling and Wein, at Munich; by Haberlandt, Lehman, Harz, Stahel, Zimmerman, Siewert, Wieski, and others, at various stations in Germany, Austria, and Hungary, and experiments have also been made in France and in Italy.

The proximate chemical composition of some of the different varieties, grown in different places, is now given and compared with some other foods of vegetable and animal origin.

Percentage composition of the soy bean.

Constituents.	Pale yellow. Japan.	Pale yellow. China.	Pale yellow. Germany, &c.	Pale yellow. India.	Brown.	Round black.	Long black.
Water	11.3	9.0	9.5	12.0	9.3	11.2	12.7
Nitrogenous matter	37.8	32.0	34.5	36.0	35.1	33.0	35.8
Fat	20.9	18.0	18.0	18.0	17.8	17.2	14.2
Carbohydrates	24.0	32.0	28.5	3.0	28.6	29.7	28.5
Fiber	2.2	4.0	4.5		4.5	4.2	4.4
Ash	3.8	5.0	5.0	4.0	4.7	4.7	4.4

It has been shown by Levallois (*Comptes-Rendus*) that the soy bean contains a special variety of sugar, many of its properties resembling mellitose; this constitutes about 10 per cent. of the soluble carbohydrates. Of the nitrogenous matters nearly all is in the form of albumenoids; a small quantity, about 1 per cent., appears as a peptone-like body, and about one-tenth to two-tenths per cent. is non-albuminoid.

Percentage Composition.

Constituents.	Peas.	Beans.	Lupins.	Lentils.	Lean beef.	Fat mutton.
Water	14.0	14.8	12.2	12.5	72.0	53.0
Nitrogenous matter	23.0	24.0	28.3	25.0	19.0	12.0
Fat	1.7	1.6	5.0	1.8	4.0	32.0
Carbohydrates	53.8	49.5	36.4	54.6	....	....
Fiber	5.0	7.0	14.1	3.6	....	....
Ash	2.5	3.1	4.0	2.5	5.0	3.0

These analyses show the greater richness of the soy beans in nitrogenous matter and in fat than the common bean and pea, and that, when the water is equalized, it more nearly approaches meat in proximate composition. The only leguminous seed of common occurrence, which contains more oil than this bean, is the earth-nut or ground-nut, *Arachis hypogæa*, which is now so largely cultivated abroad for its oil and its cake. In order to compare the soy bean straw with hay and with other straws of like nature, the following average analyses are given:

Constituents.	Meadow hay.	Bean straw.	Pea straw.	Lentil straw.	Soy bean. straw	Soy bean hulls.
Water	14.0	16.0	15.0	14.5	11.3	10.2
Nitrogenous matter	8.2	10.0	7.0	14.1	7.8	6.0
Fat	2.0	1.0	2.0	2.0	2.2	1.5
Carbohydrates	39.8	34.5	34.0	26.4	41.6	43.0
Fiber	30.0	34.0	38.0	36.6	24.9	31.0
Ash	6.0	4.5	4.0	6.4	12.2	8.3

A special variety of *Soja hispida* is cultivated in some parts of Japan as a fodder crop and cut just as the pods are fully formed. The hay made from this is much relished by horses, cattle, and sheep. A sample of a crop grown on the Imperial College of Agriculture Farm, Kornaba Tokiyo, gave on analysis:

Water	15.0
Nitrogenous matter	19.8
Fiber	35.9
Ash	6.8
Carbohydrates and fat	22.5
	100.0

It will be seen that this hay exceeds even lentil straw in the amount of nitrogenous matter it contains.

The following are means of various analyses made in Japan of food products obtained from the soy bean, and which are largely consumed there:

Percentage composition.

Constituents.	White miso.	Red miso.	Bean cheese.	Frozen bean cheese.
Water	50.7	50.4	89.0	18.7
Nitrogenous matter	5.7	10.0	5.0	48.5
Fat	} 24.4	} 18.9	3.4	28.5
Carbohydrates			2.1	2.6
Fiber	12.6	8.2	....	....
Ash	6.6	12.5	.5	1.7

The ash of *miso* consists mainly of common salt, which is added in the process of manufacture.

The ash of the soy bean was found, as a mean of several samples, to have the following percentage composition. The composition of that of the straw is also given:

Constituents.	Soy bean ash.	Straw ash.
Potash	44.5	15.4
Soda	1.1	2.2
Lime	5.6	44.2
Magnesia	9.1	15.4
Ferric oxide	.8	.8
Chlorine	.2	.2
Phosphorus pentoxide	32.7	9.4
Sulphur trioxide	6.0	6.4
Silica	....	5.5
	100.0	99.5

The crop takes from the soil a large amount of valuable mineral constituents, phosphoric acid and potash, as well as a large amount of nitrogen.

The results of the German and Austrian experiments show that where temperature is not too low, the result of the harvest as compared with that of ordinary beans or peas is exceedingly satisfactory.

The kinds most suited for cultivation there are the yellow, brown, round black, and long black varieties, *i. e.*, *pallida*, *castanea*, *atrosperma*, and *melanosperma*, especially the first three named. They require a vegetation time of about one hundred and fifty days, during which the average temperature must be about 58° F. (14.3 C.), and the sum of the heat (the average temperature multiplied by the number of days) about 2,100 C. They may be sown the beginning of May and harvested the end of September or even the beginning of October.

The seeds should not be sown deeply, not more than 1 to 1½ inches deep, and about eighteen plants to the square yard may be left after weeding and thinning out. The plants grow to a small bush about 2½ feet high, and produce pods with two to five seeds. The most suitable soil is a peaty soil, or one containing a good deal of organic matter, and the next most favorable is a calcareous soil. Nitrate of soda has been found to be a good manure for the crop in Germany and also potash salts, especially potassium sulphate. Ammonium sulphate did not give as good a return as the same amount of nitrogen in the form of nitrate; on soils poor in organic matter it would probably be better to supply the nitrogen in some organic combination, such as rape-cake, shoddy, and the like. Phosphoric acid, especially as a dicalcic phosphate was a help on some soils.

Field experiments made by myself on this crop in Japan showed that wood ashes had a good effect, and that anything like an excess of nitrogen was very harmful to

the yield of grain. In that country the plants are often sown on the dividing ridges between the plots of paddy and without any manure. The yield of seed and straw in the German experiments compares very favorably with that of peas and beans grown under the same conditions; from 2,000 to 3,000 pounds of seed and from 5,000 to 10,000 pounds of straw per acre have been obtained.

Feeding experiments with the produce have been made with pigs, sheep, oxen, and milch cows, and with very good results. The bean is a most excellent addition to other foods, especially such as are deficient in nitrogenous matter and fat. The digestion co-effients of the nitrogenous matters of the fat and of the non-nitrogenous matter of the soy bean, and also in the cake left after its pressure for oil, closely approximate to 90 in each case. As a mean of two direct experiments with soy bean straw, the digestion coefficients were found to be as follows: Nitrogenous matter 60.8, fat 6.2, fiber 33.6, and non-nitrogenous extractive matters 69.0. The hulls are rather less digestible.

The albuminoid ratio in the bean is about 1 to 2.3, in the straw 1 to 8.1, in the hulls about 1 to 20, and in the cake 1 to 1.3.

An analysis of the cake shows:

Water	13.4
Nitrogenous matter	40.3
Fiber	5.5
Carbohydrates	28.1
Fat	7.5
Ash	5.2
	100.0

In good condition it would be a valuable addition to our feeding cakes, but it is too highly valued in the East to enable it to be imported to any extent at a profit.

The soy bean plant has considerable power of resisting unfavorable climatic influences, as cold, drought, and wet; and appears to be particularly free from insect attacks, and, indeed, from all parasites; this last, if it continues, is by no means a slight advantage. The soy beans are eagerly bought by the natives of Southern Italy, an almost vegetarian race; that they are easily digested I can speak from experience, having frequently used them on my table, cooked after the manner of haricots. Taking into account the great richness of these beans in valuable food constituents, their easy digestibility, the value of the straw, and the great probability of some variety being able to be acclimatized without great trouble, this *Soja hispida* is worth consideration. The bean would form an exceedingly useful addition to the food of the poorer classes, as a substitute for a portion of the animal food which in the kitchens of the laboring classes is so wastefully cooked. One use it has already found, not altogether to be commended, viz., after roasting, as an adulterant of and substitute for coffee.

We have procured seeds of several varieties direct from Japan, and of one variety from Germany, and these are now being cultivated in the botanic garden. They were sown rather late, and the month of June has not been favorable to their growth, but some of the varieties promise fairly.

A WALK WITH THE PROFESSOR OF AGRICULTURE.

Starting from the well-kept grounds in front of the college building, under the guidance of Mr. R. Wallace, professor of agriculture, we entered a large open meadow, on which were feeding some thirty-two sheep, that represented nearly all the breeds raised in Great Britain. These sheep, as the professor tells me, are not used for experiments in breeding, but as simple apparatus in teaching and for comparing the

characteristics of the different races. There were sixteen breeds, each represented by two ewes, which were, indeed, the finest of their kind. The college keeps no rams of these various races; all the ewes were crossed last year with a Cotswold buck, and the resulting lambs fattened and sold to the butcher.

The professor pointed out the following breeds:

(1.) Of Downs: Shropshire, Oxford, Hampshire, and Southdown.

(2.) Of the Multons: Herdwicks, Highland Blackface, Lanks, and Exmore.

(3.) Of the Leicester and related breeds: Scotch Border, English Leicester, Lincoln, Long-wooled Devons, and Wensleydales.

(4.) Of the other breeds: English-bred Merinos, Romney March, and Dorset.

The lectures on sheep and their management are given by the professor in this field, with these rich illustrations close at hand.

WORKSHOPS, EXPERIMENTAL FEEDING, STABLES AND VETERINARY DEPARTMENT.

Still farther, a quarter of a mile distant from the college, and, standing near the public road, is a building with several out-houses, which contains the veterinary hospital, the various college workshops, and the experimental feeding stables.

WORKSHOPS.

We first entered the quarter wherein the workshops are located and took account of their purpose and equipment. These shops are wholly devoted to the manufacture and repair of the implements, machinery, vehicles, &c., used on the college farm, and here the students learn and practice the various handicrafts in the mechanic arts, so far as they relate to agriculture. The foremen, whom we found in the shops, assured us that the young men under their charge show a great interest in shop work. The work is voluntary, but they are incited to diligence in it by the offering of silver medals as prizes for the best work done in carpentry, lathe-work, saddlery and harness-making, wheelwright-work, horse-shoeing, and blacksmithing.

The *blacksmith shop* is fitted up with the ordinary appurtenances for smithing, and here the farm horses are shod, and the wagons, carts, plows, harrows, and other implements mended. We were shown well-made horse-shoes as samples of students' work, and told that most of the smithing was done by them.

The *lathe-room* contains five lathes on which such parts of farm implements as can be made by lathe-work are completed. The foreman here also spoke in high terms of the expertness of the young men in the use of the lathe, saying that though the work was voluntary there was no lack of enthusiasm on their part in this line.

The carpenter shop.—Here the foreman, who has twenty-one young men under his charge, exhibited with much pride a number of samples of what his pupils had done in the line of carpenter work. A well-constructed cart, a wheelbarrow, and several models of farm buildings were among the articles shown. The following is the course of practice which is completed in this department of shop work:

1. Mortise and tenon work.
2. Field gates, 1½-inch scale.
3. Dovetailing.
4. Wheelbarrows throughout.
5. Wheelwright in general.
6. Ladders of different designs.
7. Paneling.
8. Gates.
9. Windows and frames.
10. Model buildings on 1-inch scale.
11. Pit sawing.

Harness shop.—In this shop are displayed specimens of all sorts of harness and saddlery used on the farm. The workshop is above, and the man in charge claimed that his handicraft had many student experts also.

Stables for experimental feeding.—These consisted of seven or eight spacious rooms, with straw-covered floors and suitable racks and feeding boxes. They were in admirable order; indeed, the general neatness of the whole establishment was pleasant to look upon.

In these stables are kept and fed, under the direction of the professor, cattle of different ages and breeds for the purpose of testing both the efficacy of different fodder mixtures in fattening and the fattening qualities of the different races. The professor has now under experiment only three steers, a Hereford, a Short-horn, and a Devon, on which he is trying the following fodder-mixtures:

The first begins with 5 pounds oil-cake, 100 pounds swedes, and 14 pounds hay daily, and closes with 8 pounds oil-cake and the same quantities of swedes and hay.

The second is a mixture of five parts decorticated cotton-seed cake to two parts Indian corn meal; of this mixture he feeds 5 pounds at the beginning of the experiment, increasing the amount to 8 pounds at its close. The same amount of swedes and hay is fed as with the first fodder.

The times of feeding are 6 a. m., 1 p. m., and 6 p. m. In the morning one-half the oil-cake is fed with half the swedes (turnips), followed later by 6 pounds of hay. At 1 o'clock the remainder of the oil-cake and swedes is given, and at 6 hay alone is given. The same order and corresponding quantities are fed to the animal on which the fodder-mixture is being tried. The cattle are watered twice a day, and are allowed the free range of their respective stalls. Each steer is weighed daily, and his condition noted and entered in the experimental record.

Veterinary quarters.—The same building wherein are located the experimental feeding stables and the workshops contains also a series of rooms in which is the pharmacy, the hospital, and the room for Turkish baths. In the first we found a complete stock of medicines for diseased animals; the second consisted of five-box stalls for the reception of sick horses; and the third (the Turkish bath) is an ingenious contrivance for giving them a profuse sweating whenever the diagnosis requires it. A guinea a week is charged for the keeping and treatment of outside animals, and the students are required to make a written diagnosis in the case of each.

In an adjoining shed is a platform and derrick for dissections, and ranged around convenient seats for those who witness them. At least two horses are dissected here each term by the professor of veterinary medicine and his classes.

THE COLLEGE FARM.

The college farm, consisting of about 500 acres, is owned by Lord Bathurst and rented to Mr. Russell Swanwick at 36 shillings per acre on condition that all its operations and stock shall be available as means of instruction to the students. It is situated upon the southern flanks of the Cotswold Hills. The land is inferior, consisting of flat level fields, diversified with low hills, and the soil, which abounds in clay and nowhere exceeds 12 inches in depth, rests upon the limestone rock.

The farm is divided into twenty fields, which vary from 10 to nearly 70 acres. A great variety of crops are raised on the system of rotation known as the "Norfolk, four course" which is varied to meet the necessities of stock raising and market gardening. This rotation runs as follows:

First year: Mangels, swedes, turnips, or winter vetches, followed by late turnips.

Second year: Barley, and occasionally wheat.

Third year: Forage crops, mown and fed.

Fourth year: Wheat.

It will be seen from this rotation that the green crops alternate more or less regularly with the grains.

Mr. Swanwick, who has gained a high reputation at home and abroad as a breeder of the Sallie Berkshires and of superior Cotswold sheep, is a graduate of the college. The great success of the farm, both financially and educationally, is due largely to his energy and unusual business capacity. The laborers employed are under the direction of two experienced farm bailiffs, one of whom, Mr. Rutherford, is its general overseer.

A WALK ON THE FARM.

On the morning of February 8 we met Mr. Rutherford, the principal farm bailiff at the college, who conducted us across the field to the farm buildings. These are on a large scale, comprising a barn, granary, chaff

and root house, machinery and cart sheds, piggeries, cattle stalls, stables, cattle yards, ram sheds, stock yard, laborers' cottages, &c. Each building is furnished with the modern conveniences, and in one of them we found a stationary engine for thrashing, sawing, grinding, &c.

We spent an hour in the business office inspecting the farm accounts. The system on which these are kept is exceedingly simple, comprehensive, and minute. Each field has its number, and careful entries are made of the cost of labor, manuring, cultivation, and harvesting, all of which are charged against it, while its product is credited, and at the end of the year the balance on the ledger page shows the exact outcome of profit or loss.

All kinds of labor employed upon the farm is entered in the *daily farm book*, with its date, rate of pay, and the field in which it was performed. In journalizing every field and every herd of sheep, swine, horses, or cattle is charged with the labor expended upon it, and all expenditures, whether of feed, machinery, or repairs, are entered in like manner.

A separate account-book is kept, even for the farm engine which is used for thrashing, straw-cutting, wood-sawing, grinding, &c. The granary account-book shows at any time the amount and value of feed fed per week and the amount on hand. There are also separate books for cattle, sheep, and pigs, wherein are entered the date of birth, pedigree, food, care, purchases, and sales; in short, this book is a condensed history of the stock to date, and the ledger certifies its final result to the owner.

The cultivation-book records in systematic tables the rotations and kinds of crops, the expense of cultivation each day, the amount, kind, and cost of seed sown, and the amount of grain harvested; besides this a special account is kept with each crop.

The system of tabulation in all the above books is simple and convenient, and its value lies in the fact that the farmer can at any time determine his financial status.

How book-keeping and business habits are taught.—The above system of book-keeping is not only of high value in the management of the farm but it is made the means of instructing the students in the keeping of accounts and in the principles of business. Beside the systematic drill given in book-keeping by the college itself, every student is required to keep a daily farm-book, in which he gathers and enters an accurate account of the same matters as are comprised in the daily farm-book kept by the bailiff. This book he completes during the first two terms of his course, at the end of which time a blank cultivation-book, similar to that kept in the office, is placed in his hands, in which he enters all the statistics gathered by himself from the fields and their management. The completion of the cultivation-book occupies the last four terms of his course. Both books, when finished, are carefully examined and prizes are given the two which are most comprehensive and accurate and which correspond most nearly to the books kept by the

farm bailiff. In this way the theory and practice go on together, and many a young man becomes an expert accountant before his graduation.

Pigs.—We next visited the pens of the piggery, where we found and examined more than a hundred of the famous "Sallie" Berkshires, which have had extensive sale both in America and Europe. Some forty or fifty pens contained pigs of all sizes, from the youngest sucker up to the matured specimen. It was the most remarkable collection of model Berkshire forms that I had ever seen; scarcely an inferior pig could be seen among them all, and a half dozen boars and a dozen sows were shown me whose development was beyond all criticism.

The ideal Berkshire, with all the faults of his race eliminated, with every valuable point brought to perfection, had been reached in many an instance. Prominent among these was the "Duke of Monmouth," a famous boar, which took the first prize at the national fair last year. He was brought out for my inspection, and Mr. Rutherford challenged me to point out a fault in him, which I failed to do. In delicate offal, breadth of ham, and fullness of form generally, no painter of animals could sketch a better hog. The young pigs we inspected were likewise instances of the finest results of judicious breeding. They were all modeled after the same admirable pattern; the size they had attained at weaning, when they were eight weeks old, was surprising.

The prices at which these pigs are sold are proofs of their superior excellence. A fine boar which was farrowed on September 3, was contracted for at 15 guineas. Ten weeks' pigs readily brought 6 guineas each. Several mature sows had been sold for 20 guineas each.

The list of premiums taken at national and other fairs by this herd is too long for detailed insertion here. Suffice it to say they comprise ten first and eleven second prizes gained in the last two years, and that, too, in competition with the best Berkshire stock in England. This remarkable success in breeding the Sallie family is beyond question largely due to perfect management and judicious feeding. The entire herd is in the hands of a special expert, who gives them the closest attention and the most scrupulous care. All the pens I noticed were entirely clean, and the straw in them fresh and dry. The feeding is systematic and regular, and the kind and quality of the food is adapted to the age and condition of the pig. The mixture fed to young pigs contains the elements that promote growth, while a stronger feed is given to older animals.

For growing pigs the allowance is composed of two parts barley meal, two parts wheat middlings, one part pea meal, with steamed turnips or potatoes.

Mr. Rutherford informs me that they have never had a single barren sow nor an impotent boar, and that they have never lost a hog from epidemic disease.

Sheep.—Following our obliging guide, the bailiff, we next proceeded across a turnip field to a portable "lambing fold," wherein were kept a

hundred fine Cotswold ewes which were approaching the time for dropping their lambs. This inclosure is so unique that a brief description of it may be of value to American sheep breeders. In shape it is a parallelogram, about 70 by 120 feet, the sides of which are made by thatching a rough wooden frame on both sides with straw, the thatch being held firm by coarse regular stitches of hemp twine. The front side, in which is the entrance, is about 5 feet high, and against the other three sides are arranged rows of small lambing stalls (6 by 8 feet), thirty-one in all, whose roof and sides are also neatly and strongly thatched. I inspected the interior and found them perfectly warm and dry, though a heavy rain was falling. The cost of this breeding-pen was not above £5. The ewes were in the care of a shepherd who watched them continually and confined each at the time of lambing in one of these stalls. I am told that a lamb is rarely lost. At this date, February 8, twenty-five or thirty fine lambs were following their mothers in the open inclosure.

Leaving the breeding-pen we visited next the "ram shed," wherein we found six Cotswold bucks of marvelous size and beauty. One of these, a ram of surpassing excellence in weight and symmetry, had taken more prizes than any other Cotswold, or, indeed, any other sheep in England.

Some 250 large premium cards of various colors, fastened to the walls of the shed, attested the estimate in which Swanwick's Cotswolds are universally held. Among these are the first medal taken at the International Exhibition at Vienna in 1873, two silver medals taken at the Bremen International Exhibition in 1874, the Centennial medal and sweepstakes at Philadelphia in 1876 and four first prizes and gold medals at the Paris Exposition in 1878. A host of premiums given by the national and district fairs in England cannot be specified.

It will be remembered that this is the district which originated the Cotswold sheep, and where the highest excellence is attained in its breeding. The bailiff assured me that these six rams are sheared twice a year, and the average clip is 27 pounds.

Horses and cows.—Leaving the ram shed we next inspected the stables, where we met Mr. Swanwick, who showed us his stock of horses, which consisted of fifteen pure-bred hunters, all bred on the College Farm. Mr. Swanwick pointed out two fine brood mares, one of which was the dam of his famous horse Glengyle, which, at three years old, took six prizes at important shows in England in 1875, and was sold the same year for 400 guineas. Though there were several excellent animals among his stock, yet it is evident that the College Farm does not make horse-breeding a specialty, and is not as famous for its hunters as for its Cotswolds and Berkshires. Indeed, Principal McClellan declares in his Cultivation Book that—

The light, thin, breaking-up land predominating so largely over the strong, and there being little or no shelter and no rich meadows, the College Farm is essentially a sheep farm. Hence no pedigree horned stock are kept at present, but the perma-

nent stock consists of eight to ten cows selected for their milking qualities. Twenty to thirty store cattle are bought in in the autumn and fattened on roots with corn, cake, and straw chaff, in covered loose boxes and stalls. Some of these bullocks are weighed every fortnight to test the increase.

THE BAILIFF'S FIELD LECTURE.

At half past 11 we adjourned from the stables to a field not far distant, where, though the rain was falling steadily, we found the farm bailiff and a class of twelve students to whom he was giving his daily field lecture. They stood in a field of vetches where the mud was abundant, and diligently made entries in their note-books while the bailiff went on to say in quaint Scotch-English:

It is wise policy on a sheep farm like this to grow green crops for continuous winter feeding, and among these the vetch is the most available. We will therefore consider this morning the management of the vetch crop.

The seed should be sown on wheat stubble which has been thoroughly prepared by burning, plowing, and cultivating to the finest tilth. It must be enriched by spreading and harrowing in fifteen cart-loads of well-digested manure to the acre, after which, about September 1, 5 acres, prepared in this way, are sown in drills 6 inches apart. When the vetches are an inch high, or usually in about a month, the second 5 acres must be sown. After a similar interval the third crop is sown in the same way. An acre of vetches will keep 70 tegs (mature sheep) one week, so that 15 acres will suffice, with a moderate supply of turnips, to keep a flock of a hundred tegs well through the winter.

Great pains should be taken to secure the best of seed, of which 2 to 2½ bushels per acre should be sown for the first two crops, and 3 bushels for the third.

Spring vetches should be sown from February to May at the same intervals as the fall sowing already described. In spring sowing we use 3½ bushels of seed per acre, and each crop is ready for feeding in six weeks. The reason why an increased quantity of seed is required in the spring is that the crop suffers more at that season from the ravages of ins cts and rot. A crop of turnips is usually sown in June or July, after the spring vetches have been fed off.

The keeping of roots through the winter.—The bailiff further described to his class the English method of keeping root crops over winter for early spring feeding. Halting near a long clay-covered pile, 10 by 70 feet in extent, he said:

For winter keeping mangels and other roots should be piled in the field, the pile being 7 feet wide at the base and sloping toward the top, and from 40 to 70 feet in length, according to quantity. Then cover 3 or 4 inches with straw and afterward half way up with dirt a foot thick, leaving it in this condition three weeks, so that the heat may escape, at the end of which time cover the top. For feeding, the pile is opened at one end, the roots removed, washed, and allowed to stand three or four days before being fed.

Wheat.—Passing on to a wheat field, the lecturer next described the preparation of the seed and the cultivation of the crop as follows:

The seed is first prepared by a process called "pickling." One pound of blue vitriol dissolved in 6 quarts of water is thoroughly mixed with 6 bushels of the wheat, afte which a solution of 3 pounds of tar to 2 quarts of water is applied, and the whole is stirred thoroughly and allowed to partly dry; quicklime is sometimes added to hasten the drying process. The object of this treatment of the seed is to prevent rotting in the ground.

The field has been previously prepared by plowing, cultivating, manuring, harrowing, and rolling, and the seed is now sown in drills, 2 to $2\frac{1}{4}$ bushels to the acre. After the seed is in, the ground is carefully harrowed and an application of soot is made to prevent slugs. About the first of May all noxious weeds are pulled out and removed. If the crop be sickly looking it is top dressed by spreading a mixture of 100 pounds nitrate of soda and 2 bushels of wood ashes. When the plants are 3 or 4 inches high the whole crop is hoed, either by hand, the usual way, or with the horse hoe. Hand hoeing is paid for at the rate of 5 shillings per acre, which is two days' work. To avoid waste during harvesting, the grain is cut before it is thoroughly ripened and stored in a loft over the thrashing-room.

Subjoined is a lacture given before the students by H. J. Little, R.A.S., senior professor of agriculture. It is appended to my report as a sample of the instruction in agriculture given here. As a dissertation upon the necessity and method of rotation of crops it is of great value.

ROTATIONS.

A system of rotation of crops is the foundation of modern husbandry. Primitive agriculture was satisfied with the yield of mother earth in such proportion as she gave spontaneously, or with no other preparation than plowing or digging and sowing such crops as were required for the sustenance of man. With the increase of population such methods have had to yield to more enlightened systems, and though we see even at the present time great continents farmed without method and without plan, nothing can be more certain tnat in some not very remote age they must revert to the systems by which alone can earth be made to satisfy the necessities of ever-increasing millions of the human race.

But even the primitive methods of agriculture, though wanting in development, satisfied to some extent the conditions which earth imposes on those who wish to reap her fruits. Before root culture was known, periods of alternate grass and corn were found to give sufficient for the food of man, but in the very early days of systematic husbandry it may be taken for granted that the disovery was made that exhaustion was soon produced in the soil by the endeavor to produce successive cereals, or indeed crops of the same species of any kind.

And in the present day, though we see in America and Australia, owing to the prodigality of nature, which, for thousands of years, has been working with unsparing hand on regions scarcely traversed by the human foot, a mine of treasure which bids fair to be rifled by mankind in as many years as it took ages to form, it cannot be doubted that when the first flash of wheat growing has robbed that virgin soil of its fertile elements, old methods and old rotations will be thrust upon the cultivation.

Already, indeed, this is shown by the complete exhaustion of the soil in the older-peopled States of the Union; and although, undoubtedly, this exhaustion is in part owing to ignorance or neglect of other principles of husbandry, and notably of proper manuring of the land, it is certain it proceeds, in great measure, from the omission of the proper rotation of crops from the scheme of husbandry.

There seems to be two reasons why rotations of crops are so desirable: (1) because, though all crops exhaust the soil more or less, they do not do so in equal proportion, nor indeed in the elements which they abstract; and certain crops therefore leave the land naturally adapted for the succession of crops of another kind; (2) because such rotations give scope for the cultivation of crops which are mainly returned to the land again in the form of manure. The *incapacity*, however, of nearly all land to grow satisfactory crops of some plants, notably of red clover, except at distant intervals, is well known. Then again, too frequent cropping of one kind produces *disease* in some species of plants, as "finger and toe" in turnips. These of themselves would be sufficient reasons for placing certain crops at intervals in rotations; but there are others which make such rotations almost indispensable. The mechanical state in

which the soil is left by certain plants has no small influence upon the capacity of the following crop for assimilating the food of the soil. How much is due to that disintegration of subsoil caused by the passage of deep-rooted plants, how much by the fact that such plants draw most of their sustenance from the subsoil itself, and how much by the different *action* of fibrous and fleshy-rooted plants, can scarcely be said to be known at present, but science, it may be added, is rapidly filling up the void in our knowledge even in these particulars. What we do understand about the rotation of crops is, then, that on all *old* soils (as distinguished from those virgin ones which have never been cultivated) they are indispensable for profitable agriculture, unless, indeed, we except the somewhat doubtful experiments of recent years as proving that on certain soils, with certain manures, remunerative crops of cereals may be grown in succession for a lengthened period. Even admitting this, the value of the principle is not impaired, because it is certain that on the majority of soils they are absolutely indispensable according to our present lights.

Now, admitting the *principle* which has been definitely established by *practice* in every country where agriculture has been studied, we come to a consideration of some of the methods adopted in our own land. The most advantageous succession of crops in this, as in other countries, is generally known from *experience*.

It will vary much with climate and with soil, but it will generally be found that some broad principle underlies it, however it may be modified or inverted. Probably there is no rotation so common as that known as the four-course: (1) turnips, (2) barley, (3) seeds, (4) wheat. It is difficult to say when this plan, so beautiful in its simplicity, was introduced into English agriculture, but it is probable that it was not long after the introduction of the turnip itself. It has indeed one fault (to be presently noted), but otherwise it is a model rotation.

Now, examine this course a little in detail, what do we find? We find the cereal crops put apart by a year, and following such other crops as are not only suitable as forerunners to their production, but which leave the land ready for cultivation for them at a suitable time. Wheat cannot readily follow turnips, because the latter crop must be consumed on the land; but this takes place in time for the barley crop, which, therefore, obviates that difficulty. But no sooner are the turnips ready for stock food than the farmer can spare some of his seed land to be broken up for wheat which there is no difficulty, therefore, in sowing at the proper time of year.

Then, again, consider the turnip crop and the part it takes in the rotation. At the end of the course comes the cleansing and fertilizing turnip crop—mark its place. The wheat crop has left the poor soil comparatively exhausted and possibly slightly foul. The turnips, which are not sown till the middle of May or beginning of June in such a climate, give ample time for that thorough cleaning of the soil which is so necessary in modern agriculture. In manures applied for the production of the crops itself, or made by the consumption of substances fed on the land by the sheep consuming the crop, it may be taken for granted that a restoration of elements in greater proportion than those abstracted is made to the soil, and thus one of the great principles of scientific agriculture is maintained. The barley crop is an exhaustive crop, no doubt, but it is followed by clover, the great proportion of which is fed on the land. But even in the case of that, which is mown and removed, it is to be remembered that clover is one of those plants which has the property in an eminent degree, of receiving from the soil and the air and storing up in the land in its roots those nitrogenous elements which are so peculiarly valuable to the succeeding crop. Dr. Voelcker found in a good crop of clover that the roots in the soil weighed about three tons, and contained almost exactly 100 pounds of nitrogen to the acre. This is almost double the nitrogen present in the average produce of an acre of wheat. On the same soil a *bad* crop of clover only produced 31 pounds of nitrogen from its roots, showing the great importance of securing a good crop of this plant.

Whether, therefore, considered scientifically or practically, this four-course rotation may be said to be almost perfect. The elements abstracted from the land in the

turnip crop are more than restored to it again in the consumption of that crop, and the clover plant, whether mown for hay or harvested for seed or grazed by cattle, has that peculiar quality of accumulating nitrogen in the soil which makes it in some respects one of the most valuable plants known to the husbandman. Even in America, which I have spoken of as remarkable for its contemptuous neglect of scientific agriculture. it is found that an occasional crop of red clover, *plowed in entirely*, has a remarkably invigorating influence on the succeeding crops of wheat.

But nature pays us out for the great anomaly of which I have spoken, because anomalous this crop is in many respects. Four tons per acre from two mowings is by no means an unusual crop : but such a crop yields on analysis no less than 224 pounds nitrogen, 51 pounds phosphoric acid, 29 pounds sulphuric acid, 201 pounds lime, 57 pounds magnesia, and 134 pounds potash. to most of which substances the soil is greatly indebted for its fertility. Nature, I say, pays us out for the anomaly of granting us a crop which, after removing many of the most valuable elements from our soils, leaves it in some way more valuable than before, by a stubborn refusal to grow this crop again except after a considerable interval. And this is what I alluded to just now when I said that one drawback might be alleged against the four-course system. Modifications of it have therefore sprung up to overcome this difficulty. In some cases *peas* or *beans* take the place of clover when it recurs in the rotation the second time. The latter crop is, however, not adapted for the description of land where the rotation was first adopted—I mean the weak and light lands of Norfolk. In lieu, therefore, of frequent repetition of clover, there *saurifoin* is much grown. It is plowed up in the autumn just the same as clover, and is not allowed to remain down several years (as in some parts) thus interfering with the regular course of the rotation. But whatever modification is practical with regard to the clover crop, it generally comes to this: "Put your clover crops apart as far as you can in your rotations if you wish successful ones." Probably in most parts of the Kingdom you would learn from experienced agriculturists that seven or eight years is the limit in which it would not be safe to take more than one clover crop, though I am myself acquainted with districts where red clover can be successfully grown every four or five years. This, however, is such an unusual circumstance that, though it deserves mention, it must not be taken as anything but the exception to a well-known and recognized rule.

There are some parts of the country where rotations are almost needless and where the simple rules which might be given to an intending agriculturist might be briefly summed up: Manure plentifully, cleanse when required, only take two white straw crops in four, and don't attempt clover too often. I am now talking of soils which will grow almost any crop, wheat, barley, oats. peas, beans, mangels, coliseed or rape, mustard, potatoes, &c. But it may safely be said that there are no good soils on which proper rotations do not conduce to profitable agriculture. For some of the yet unenumerated benefits are that they bring constant and suitable employment to our laborers, according to the seasons of the year, and thus enable a staff of men to be profitably employed; and moreover that they provide our live stock with a succession of suitable food. These reasons (and they are very cogent ones) must be added to those before given in favor of these rotations.

I go on now to enumerate a few courses which have been found advantageous according to soil and circumstances in different parts of the country, and you will see that most of them spring in some degree from that old four-course shift which we have been considering. In the north of England the clover mixed with grass seeds is kept down two years in other respects the rotation is unaltered. It thus becomes: (1) turnips, (2) barley, (3) seeds, (4) seeds, (5) wheat. In Northamptonshire and Bedfordshire, *on good land*, two years corn crops are on the contrary taken at the beginning of the course instead of one, thus: (1) Turnips, (2) barley, (3) barley, (4) seeds, (5) wheat. The reason of this is obvious; the first crop of barley after turnips, where cake is consumed in any quantity, is apt to be too bulky and thus to smother the

young plant of seed; the succeeding crop has not this fault, and thus gives them a better chance of making a perfect plant. In East Lothian an ordinary rotation is (1) turnips, (2) barley, (3) seeds, (4) oats, (5) potatoes every twelfth year, and beans alternately with this crop every twelfth year, (6) wheat. This is a modification which throws the clover shift further apart, and gives scope for the cultivation of the very profitable crop of potatoes on suitable soils.

We now come to one which I have found almost universal in Warwickshire and the neighboring districts of Worcestershire, and which, I believe, is common in this immediate neighborhood as well: Turnips (or mangels), barley, seeds, wheat, beans or peas, wheat. On some of the poor land of the Cotswold district I am told that turnips take the place of beans (the fifth crop in the rotation) and that rye is sown for feeding off immediately after the removal of the wheat crop (the last in the rotation), the said rye being followed immediately by white turnips. Or, again, it is not unusual to take a crop of oats or barley after the wheat crop of the course, thus changing it into a five-course shift.

It is scarcely necessary to observe how all these rotations which I have enumerated owe their foundation to the old Norfolk system. Where peas and beans are introduced they form an excellent preparation for the wheat which follows, they being plants which, like clover, have the valuable property of either drawing the whole of their nitrogen from the air or in some yet unexplained manner helping its development in an assimilable condition in the soil itself.

Perhaps it may be useful here to say a few words on a system which has been successfully practiced in some parts of the midland counties for many years, and which offers many advantages to high farmers by largely increasing their root area without a deviation from the regular course of the district. In some of the gravelly loam parts of Warwickshire and Worcestershire it is common to interpolate a crop of turnips between the beans and wheat, which conclude the course.

Winter beans (the land having previously received a dressing of twelve one-horse cart-loads of farm-yard manure) are planted early in November after one plowing, 2 bushels per acre being drilled in double rows, 9 inches apart; the distance between each double row is 27 inches. This method leaves ample room for hand and horse hoeing, which is vigorously prosecuted among them throughout the spring. In the third week in May, and just previous to the final horse-hoeing, a seed barrow, cleverly prepared for this purpose, is run over the land and drops in the center of each wide row the very small quantity of half a pound per acre of white turnip seed. The difficulty is, of course, to get this small quantity of seed evenly distributed, and the result is so thinly scattered a plant that no hoeing or thinning out in any way is required. The horse-hoe follows and completes the operation, at one stroke giving a final touch to the bean crop, and covering at the same time the turnip seed. At the time of harvest it might be thought that the machine could not be safely employed; but, on the contrary, without material injury to the turnip crop (which is by that time making considerable progress), that invaluable implement is used, and thus no extra cost is incurred in consequence of the extra crop. The reaper cuts the beans entirely the same way as the drills run, the turning being accomplished upon the head lands, and the driving wheels running upon the stubble, and being kept clear of the young turnips. It was certainly a novel experience to find among the bean-straw, in the stack sides, large turnip leaves which had been cut by the reaping machine at the time of harvest; but a careful examination of the roots themselves satisfied me that little, if any, damage had occurred to them from its use, and that a valuable and nutritious crop of turnips had, by this admirable plan, been added to the resources of the farm at a minimum cost. As soon as the bean crop is harvested the broad-share is run between the rows of turnips, in order to cut the stubble and destroy any weeds which may remain. The operation is now complete, and by November the "extra crop" is under consumption by sheep. The crop last year was a very good one. Some of the seed had fallen singly, and in that case the turnips were a very good size; others

again had fallen in groups of two to five, but from the ample room on all sides of the plants, owing to the width of the rows and the comparative regularity of distribution, even these "bunched turnips" had thrown themselves out and produced very fair-sized roots.

On the pea portion of the break the same system of extra cropping is adopted, but a different course is pursued. About 4 or 5 acres is generally drilled 14 inches apart, and at the rate of 3 bushels per acre, some early variety being selected (such as Sangster's No. 1), which may be suitable for pulling green for the market. Between every third row, and at a distance of 42 inches apart every way, drum-head cabbages are planted about the beginning of May. The peas are sold to pick for the Birmingham market, and last year the satisfactory price of £10 10s. per acre was realized, the haulm being left, and the purchaser paying all expense of labor in picking. It will be readily understood with what facility the subsequent cultivation of the cabbage crop is attended. The horse-hoe is enabled to work without hindrance between the rows in each direction and very little hand labor is therefore required. The cabbage crop at our November visit was capital. It was already stocked with the ewes, which were eating half a pound of rape cake and half a pint of Indian corn, and were thus adding to the fertility of the land. Only part of this break (as I have mentioned) is thus treated. The remainder is planted with peas for a crop; but it must not be supposed that where they are thus allowed to remain, no extra crop is used. In this case, immediately they are harvested, rape, mustard, or turnips are quickly put in, whichever may be most required according to the circumstances of the young sheep stock.

Wheat follows each and all of these extra crops and completes the rotation.

I only mention this subject incidentally and as showing what "wheels within wheels" there may be, so to speak, even in *rotations* of cropping. But there is much land in Great Britain to which no adaptation of the real Norfolk system can be profitably applied, because it will not grow turnips, either from some innate disability or because such a crop ruins the land in the carting-off or feeding-off stages of its cultivation. On some of this land dead fallow is no doubt a necessity, but dead fallows cannot be said to indicate a very high style of farming, and for my part I always look with some suspicion on the agriculture of those parts of the country where they are predominant. If roots cannot be consumed on the land in winter a crop of equivalent restorative value should take their place in summer. Vetches will, to a certain extent, effect this purpose, and cabbage can be grown so as to be ready for consumption in almost any desired month in the year. When, therefore, the land seems naturally inimical to turnips, a bare fallow is, I think, a somewhat doubtful advantage. I know something of this description of land. In my own neighborhood you may take a day's journey without finding a single field of turnips. The oldest of rotations followed on such lands was generally (1) rape fed off in winter, (2) oats, (3) wheat, (4) seeds, beans or peas, (5) wheat. Perhaps the primitive form of this was simply rape fed off, oats, wheat, a rotation which it may be remarked even now lingers on among some penurious farmers, who wish to spend as small an amount as possible in labor. Even this simplest of all rotations is, therefore, not without its advantages. The rape for winter-feeding of sheep is not sown until July, which gives an opportunity of fallowing the land far beyond the period allowed by any other root crop, and encourages the almost total destruction of weeds which would prove prejudicial to the corn crops.

The peculiarity of this rotation and its modifications is the large proportion of the area allotted to corn crops. Thus, in the first-named course, three-fifths of the arable land is always in cereals; in the latter two-thirds. Of course, only land naturally rich in the elements of fertility could stand this, but that the Fen lands of Lincolnshire, Cambridgeshire, and the Marsh land district of Norfolk have done so for years there can be no question. In 1769, Arthur Young, traveling through South Lincolnshire, found many extraordinary courses of cropping. Thus he enumerates the fol-

lowing: Fallow, wheat, wheat, beans, barley, which he remarks on as "very bad"; and coleseed eaten, oats, oats, barley, as "much worse." He then comes to grass broken up for flax, turnips, flax, oats, oats, wheat, fallow. "This," he says, "it must be confessed, is as admirable a system of exhaustion as can be met with." Again, in Norfolk *Marshland*, a district of rich, though low-lying land, entirely alluvial, he came upon some equally peculiar rotations, thus: Fallow, oats, oats, wheat, spring-wheat; and, again, wheat, wheat, oats, potatoes, wheat; and, once more, wheat, oats, wheat, potatoes, wheat. He exclaims satirically upon these courses, "Bravo, Marshland lads!"

But though I have said that properly devised rotations are of the very essence of good farming, it would, in many cases, be extremely unwise to bind the tenant of certain descriptions of land. For instance, I have just myself concluded, on one of my own fields, the following somewhat eccentric rotation of crops: Coleseed fed off, oats, wheat, beans, wheat, barley, seeds, wheat, peas, wheat, and I have no hesitation in asserting that that land has been uninjured by the succession of crops mentioned.

Again, I have known land in my own neighborhood cropped alternately with beans and wheat for twenty years without an application of manure to either crop, and without exhibiting any diminution of produce. This, it must be admitted, is only suited to rich loams or clays of a peculiar character.

On my own farm I have a field which for twenty-three years has grown alternate crops of mangels and wheat without any variation, the whole of the mangel being removed from the land for consumption by cattle. The mangel crop has probably averaged 28 tons per acre, one year with another, and the wheat crop 36 bushels. (The mangels are manured with 20 loads farm-yard manure, 3 cwt. bone superphosphate, and occasionally 2 cwt. Peruvian guano per acre. The wheat is always unmanured.) This is a case where the nature of the land rendering it peculiarly suitable, and its proximity to the homestead peculiarly convenient, for the production of mangels, an apparently exhausting course has been followed out for this lengthened period with signal success.

But in this case, as in the other one quoted above, the question of manures for each crop has been carefully considered, and, taking into account the nature and characteristics of the land, it would probably be found on analysis of the soil and the crops from year to year, that no more than the usual surplus beyond the manures supplied had been abstracted from the soil. I mean, of course, that exhausting as such courses of cropping apparently are, if manures be judiciously applied, they are probably not more so than the old-fashioned rotations under which the land has maintained its fertility for generations.

But with regard to the exhaustion produced by certain rotations, the whole thing resolves itself into the question of the proper tillage of the land and the application of manures. Sir J. B. Lawes is of the opinion that he has not deteriorated his experimental plots by the growth of wheat for thirty-eight years in succession. Dr. Voelcker does not think that Mr. Prout is diminishing the condition of his land at Sawbridgeworth by his system, but in both these cases *science* has been called in to aid the farmer, and a restitution has been made, upon principle, of such proportion of the abstracted elements as she shows to be necessary.

Let us, therefore, consider this question of rotation for a few minutes in a scientific light.

We have seen that practically well-devised rotations are beneficial in agriculture, because under them crops are better and freer from disease; because some crops exhaust the land for themselves but improve it for their successors; because they provide regular employment for laborers and a succession of suitable food for cattle. We have seen that it would not be wise or beneficial to lay down any hard and fast rule with regard to them, because climate, soil, labor difficulties, proximity to market, facility for the purchase of manure, and many other circumstances may render it advisable to modify or entirely alter the usually followed plans. But notwithstanding

these exceptions, we may safely come back to the axiom with which we started—that a rotation of crops is the foundation of good husbandry; and scientifically we are on as good grounds for making this assertion as we are practically.

For Sir J. B. Lawes's and Dr. Voelcker's experiments prove that there is a constant waste of nitrates from the soil by drainage and that practically this waste only occurs in winter. Moreover, nitrification in the soil is only carried on during the warmer period of the year, and the green crops, the roots sown late in spring, and the clover sown the previous year are therefore in a stage of growth which permits them to appropriate the nitrates of the soil as quickly as formed. Not so with the cereals. Their active growth ceases at flowering time, when nitrification has not long commenced. The nitrates on the cereal fields are therefore to a great extent wasted, whilst those in the green and root crops, which are in an active state of growth, are appropriated and retained.

Again, there can be but little doubt that the leguminous crops draw their supplies of nitrogen from entirely different sources to the cereals, and although their action in this particular has not been fully explained by science at present, the very fact that a crop of beans removes more than double as much nitrogen from the soil as a crop of wheat, whilst it leaves the land in fine condition for a crop of this latter cereal, indicates that such must be the case. Further, in the removal of other substances beside nitrogen, the cereal, leguminous, and root crops differ exceedingly. Thus, whilst wheat removes only about 28 pounds of potash, swedes abstract 81 pounds, and mangels 262 pounds. But of silica, whilst wheat removes 111 pounds, 2 tons of red clover hay only removes 7 pounds, and beans scarcely more than that insignificant amount. These variations, though they do not resolve everything, clearly indicate how scientifically the benefit of these rotations can be explained.

And now I will conclude with a very few words, practically summing up our consideration of the subject, and these shall be addressed to those who are in future contemplating the important business of estate management as their calling. Though rotations are, as we have seen, of the highest importance to successful agriculture, it is possible that by scientific knowledge of the ingredients of our soils and the proper employment of manures, they may in the future be to some extent dispensed with. It is certainly unreasonable in the present day to treat the ignorant farmer and the enlightened one as on the same footing. Though I would recommend certain restrictions in the majority of cases to be maintained, the enforcement of which could be put in practice if necessary, and though I would recommend a watchful eye to be kept upon cropping, I would give very considerable license to experienced and good men. The large consumption of artificial food and increased use of artificial manures have rendered such restrictions less necessary. The good farmer will always find it to his advantage to practice proper rotations. The agent can alway satisfy himself by a glance at fields and stock-yard whether the farm is properly tilled or in process of gradual impoverishment. If, according to Sir J. B. Lawes's opinion, "rent is paid for the right to remove, without restriction, a certain amount of the stock of fertility in the soil," if, I say, such an axiom as this can be established, then it must be admitted that it is equally hopeless and unwise to bind the tenant, in the face of increasing competition with the world, with restrictive covenants only applicable to an entirely different state of agriculture. At present we may be said to be standing at the threshhold of our information with regard to soil exhaustion caused by various rotations, and even by different crops. But one thing seems at least clear, that he who imparts the largest amount of food and manure to his fields to counterbalance the continual drain in produce sold will more surely retain that mysterious property called fertility, than he, who, trusting entirely to the efforts of nature to recover herself, returns naught but what she in the elaboration of her own secret processes has herself given him. "Rational agriculture," says Liebig, "is based upon the principle of restitution, and however this may seem to clash with Sir J. B. Lawes's dictum, the two sayings are not contrary in spirit, for though it is probable that all rotations of crops exhaust the land by degrees, such exhaustion will take place more slowly in proportion to the artifical fertility imparted to the soil."

SKETCH OF THE ROYAL AGRICULTURAL COLLEGE AT CIRENCESTER, ENGLAND.

History.—The Royal Agricultural College near Cirencester was established in 1845 by a company of noblemen, headed by Prince Albert. It was incorporated at the same date under a charter granted by Queen Victoria. The sale of corporation shares realized a sum sufficient to erect the fine Gothic structure used as the main college building. The charter provides for six regular resident professors, beside the principal, and empowers the college to grant certificates of proficiency and diplomas of membership. In 1880 the institution was first named by Her Majesty the Queen the "Royal Agricultural College of England." There is no endowment fund; the support of the institution depends wholly upon the patronage of the association and students' fees.

The purpose of the college, as set forth in the charter, is to train scientific and practical agriculturists. It aims "to teach the science of agriculture and the various sciences connected therewith and the practical application thereof in the cultivation of the soil and the rearing and management of stock." It seeks, by teaching the scientific principles which govern agricultural operations in all parts of the world, together with methods and processes of sound agricultural practice, to train its students effectively for the profession and business of the agriculturist, whether at home, in India, or in the colonies, and its courses of study are adapted expressly to meet the needs of the three following classes:

I. Future land owners.

II. Future land agents or surveyors; stewards and managers of estates.

III. Future colonists and employés in Indian agriculture.

Over and above the special training thus furnished, the institution supplies the advantages of a university course, in which is included the means of intellectual and moral discipline and preparation for the duties of country gentlemen who have the care of large estates.

The organization.—The formal patron of the institution is the Prince of Wales, and its president is the Duke of Marlborough. Corresponding to the board of trustees who have legal control of our American national schools is a committee of management, consisting of ten members, four of whom belong to the nobility. The following list comprises the board of instruction, as it stands on the college prospectus: Principal, Rev. John B. M'Clellan, M. A., double first-class man in honors and late fellow of Trinity College, Cambridge; agriculture and rural economy, Prof. J. H. Little, member of council, R. A. S., and Prof. R. Wallace, F. H. A. S.; tenant and director of the college farm, Russell Swanwick, esq., M. R. A. C.; assistant practical instructors and bailiffs, Mr. Rutherford, Mr. R. Rutherford; chemistry, Prof. E. Kinch, F. C. S., F. I. C., &c.; assistants, Mr. H. H. Robinson, B. A., Magdalen College, Oxford, and Mr. W. James; geology and biology, Prof.

Allen Harker, late of the Zoological Station, Naples; special lecturer on entomology, Miss E. A. Ormerod, consulting entomologist, R. A. S.; mathematics and physics, Prof. H. Ohm, M. A., Emmanuel College, Cambridge; land surveying, practical engineering, and book-keeping, Prof. A. W. Thompson, C. E. B. Sc.; veterinary medicine and surgery, Prof. W. F. Garside, M. R. C. V. S.; agricultural law, Prof. W. M. Fawcett, barrister-at-law; building materials and construction, Prof. F. W. Waller, F. R. I. B. A.; estate management, Prof. T. J. Elliot, M. R. A. C.; drawing, Mr. James Miller, art master.

Honorary professors.—Prof. G. T. Brown, professor of cattle pathology at the Royal Veterinary College, London; John Coleman, esq., M. R. A. C., formerly professor of agriculture at this college; Dr. Augustus Voelcker, T. R. S., consulting chemist to the Royal Agricultural Society.

In addition to the above, there are five foremen and teachers of handicrafts connected with the farm, viz., lathe work, carpentry and wheelright work, smith work and shoeing, saddlery and harness making, gardening.

There is also a body called the board of studies, whose duty is to select and arrange the courses of instruction. The graduates who have obtained the diploma of the college (M. R. A. C.) number 250, of whom 24 have taken the diploma of Fellowship of the Highland and Agricultural Society of Scotland.

The buildings.—The college building, which stands near the extensive Oakley Park, owned by Lord Bathurst, is an imposing Gothic structure, located on the college farm, a mile and a quarter from Cirencester. It has a front of 200 feet in extent, and contains the apartments of the resident professors, the students' dormatories and study-rooms, the dining-hall, library, museum, lecture-rooms, class-rooms and laboratories. Grouped around the main building at different distances are the cricket pavilion, botanic garden, veterinary hospital, forges, work-shops, and the college farm buildings, most of which I have already described.

The chapel, which is an adjunct to the main building, is a tasteful Gothic structure, built from the contributions of private individuals in 1846. The services conducted in it are those of the Church of England, and the students gather here for prayers twice a day on week days and twice for Sunday service.

Meteorological station.—Connected with the college is a meteorological station, which is supplied with instruments for daily observations, which are made and reported to the Government Meteorological Office.

The government and discipline.—A striking feature in the management of the institution is that the entire government and control, both of faculty and students, is in the hands of the principal, who is responsible to the committee of management alone. In the management of the entire enterprise his powers are plenary and his authority unquestioned. He appoints and removes professors, regulates the time and number of the lectures, organizes the classes, and settles all questions

respecting the work of the faculty. The discipline of the students is wholly in his hands, penalties are inflicted and rewards bestowed according to his judgment, and, in short, he holds supreme control over all the departments.

Admission and dismission of students.—There are three terms in the year, beginning, respectively, January 28, May 28, and October 6, and students are admitted at the beginning of each, without entrance examinations. The regular form of application, which I have appended because of its contrast with the rules of admission to similar schools in America, makes moral character and good health of more account as a qualification for entrance than scholastic preparation. The principal assured me, however, that the general standard of education in the grammar schools was so high as to make it safe to admit their pupils to the college without question.

In and out students.—The in-students, so called, are those who reside in the building, and are required to take the prescribed course of study. They must be eighteen years of age on admission.

The out-students, who are required to be at least twenty-one years of age, and may be either married or unmarried, board in the town, and are permitted to attend any course of lectures or pursue any branch of practical study, at their option.

There are about 70 in-students and about one-tenth of these graduate. The out-students number 21, eight of whom are alumni of Oxford University.

The expense of students.—The cost of attendance at this college is much greater than at corresponding schools in the United States.

FORM OF APPLICATION FOR ADMISSION AS IN-STUDENT.

1. Name, in full, of the candidate for admission.

2. Date of birth.

3. Parent's or guardian's name, and which. Profession of ditto. Full postal address.

4. Mention the schools or other places of instruction where the candidate has been during the last six years, giving the time spent at each, and the addresses of the principals.

5. Has he been rusticated or removed from any college, school, private tutor's, or other place of residence or occupation for misconduct? If so, state the name and address.

6. Has he been vaccinated? Has he had the small-pox? Measles? Is his health generally good?

7. Has he ever been of unsound mind? Is he predisposed to any sudden or dangerous malady? Has he had any infectious disorder or severe illness within the last six months? If so, furnish doctor's certificate. In case of illness, is it his parents' wish he should be attended by the accredited medical officer of the college?

8. Is it his parents' wish that he should have a private room, if one be vacant? (See prospectus.)

9. Is it his parents' wish that he should be allowed to have wine in his own room at his own expense, by permission of the principal? If so, to what extent?

N. B.—No spirits allowed except under medical order, or at the special desire of parents or guardians.

10. Is there any other matter of which the college authorities should be informed?

*Testimonial to moral character to be signed by the master, tutor, or other person or persons (not being the parent or guardian) under whose care the candidate has been during the two years immediately preceding the application for admission.**

I hereby certify that ——— ——— was under my care and instruction [or well known to me*] from ——— 18—, to ——— 18—, and that, to the best of my belief, he is of good moral character, not addicted to any depraved or vicious habit, and not removed from my own or other care in consequence of any misconduct.

Name: ——— ———.

Address: ——— ———.

Profession, &c., ———. Date, ———.

Undertaking to be signed by the candidate for admission.

I, the undersigned ——— ———, hereby sincerely promise that, if I be admitted a student of the Royal Agricultural College, I will honorably conform to all the rules and regulations of the college relating to in-students, and in every way observe such a standard of conduct as shall command respect, and as shall maintain the honor of the college.

Signed: ——— ———.

Counter signature of parent or guardian: ——— ———.

Dated, ——— —, ——.

Certificate to be signed by the parent or guardian, or student (if over age).

I hereby certify that the answers given to each and all of the above questions are, to the best of my belief, explicit and accurate, and I undertake to pay for the above-named ——— the college fees on the conditions mentioned on the page facing this, of which I retain a duplicate.

Signed: ——— ———.

Dated, ——— —, ——.

Date of admission: ——— —, ——.

An in-student pays £45 per term, or £135 per annum. The out-student pays £25 per term tuition or £75 per year. This is five times the cost of attendance at the Agricultural College of Iowa.

Incentives to study.—In this college numerous prizes are given, mainly in money, for excellent scholarship in the various sciences that compose its curriculum; there is in consequence among the students an eager strife for the highest standing and a very successful competitor may gain the large sum of £75 per year.

The Government of Bengal gives £1,200 annually in scholarships, which are bestowed upon the native Indian graduates of the University of Calcutta.

The college itself awards every year two hundred prizes, which are conferred upon students having maximum marks in agriculture, agricultural law, estate management, and architecture. It gives also silver medals and books as prizes for excellence in the various handicrafts of farming, such as shoeing, plowing, sheep-shearing, carpentry, harness work, farm accounts, &c. In addition to the above three gold medals are awarded

* If the candidate has been at home during part of the period (vacations excepted), the testimonial for such time must be signed by the clergyman of the parish or other minister of religion or magistrate to whom the candidate has been well known.

for the highest attainments shown in the final examinations for the diploma.

General interest among students.—One cannot commend too highly the great earnestness with which the young men pursue their various duties, whether in the lecture-room or the farm. Wherever I met students I was impressed with the absorbing attention they were giving the work or study they had in hand. All the exercises which I attended were characterized by the most perfect order and decorum. The moral sentiment among these young men seems to be unusually high, and the principal manages them mainly by paternal kindness.

Method of instruction.—The entire instruction throughout the course is given by lectures only. The exercise known in the United States as recitation is wholly unknown here. The classes take careful and complete notes on the matter presented by the lecturer, then consult works of reference on the same subject, and prepare themselves for a weekly written examination of some three hours, by which their standing is in part determined. Written and oral examinations are held at the close of the term, and the final examinations for the diploma on the completion of the course covers the entire ground passed over during the preceding terms. (See examples of questions in these examinations.

The course of instruction, practical and scientific, embraces the latest scientific knowledge and practical experience, and is adapted to the training of practical agriculturists, land agents, stewards, surveyors, &c. It comprises lectures, field inspections, laboratory practice, veterinary hospital practice, mechanical work of the farm, and experiments in the field. Foremost stands the science and practice of agriculture, and along with these are taught the related sciences, which are applied by the practical agriculturist, including chemistry, geology, botany, zoology, mechanics, physics, veterinary surgery, mensuration, practical engineering, land surveying, book-keeping, and architecture. The practical instruction includes estate management, forestry, agricultural law, and farm architecture.

The following syllabus of studies will give a general notion of the extent and practical character of the subjects pursued:

Terms 1 *and* 2, *class* 1.—Agriculture (soils, manures, implements, labor, buildings, &c.), chemistry (inorganic), book-keeping, mensuration, physics, geology or botany or zoology, veterinary anatomy and physiology, drawing (plan).

Terms 3 *and* 4, *class* 2.—Agriculture (tillage, crops, &c.), chemistry (organic), book-keeping, surveying, physics, geology or botany or zoology, veterinary pathology, drawing (machinery).

Terms 5 *and* 6, *class* 3.—Agriculture (stock, dairy farming, economics, &c.), chemistry (agricultural), book-keeping, leveling and engineering, physics, mechanics, geology or botany or zoology, veterinary therapeutics, obstetrics, &c., drawing (design).

Agricultural law in the winter session, building materials or construc-

tion in the spring session, and estate management in the summer session each year. Indian and colonial agriculture separately or inclusively.

I append the following detailed account of the chemical laboratory work, kindly prepared for my report by Professor Kinch, as a specimen of the fullness and minuteness with which the operations of each department are carried on.

CHEMICAL LABORATORY WORK.

First term.—Chemical manipulation: practical lessons on crystallization, filtration, &c. Preparation of gases, as oxygen, hydrogen, carbon, dioxide, ammonia, &c. Examinations of soils, waters, foods. &c. Blow-pipe experience, *vide* pt. 1. Laboratory Guide, by A. H. Church.

Second term.—Similar to first term, but more advanced, *e. g.*, differerent samples of water may be given to the student to test qualitatively and relatively for the most common impurities, as lime, chlorine, sulphuric acid, ammonia, nitric acid, behavior with potassium, permanganate, and the like. The general style of the lessons is that in Church's Laboratory Guide, modified to suit circumstances.

Third term.—Reactions of bases and acids.

Fourth term.—Qualitative analysis of salts, mixtures, manures, &c.

Fifth term.—Same as fourth term.

Sixth term.—Quantitative analysis specially of agricultural value, manures, foods, soils, and farm products, *e. g.*, a student, when sufficiently advanced, is given a superphosphate which has been previously carefully analyzed by the professor or his assistants, and required to determine the percentage of water, organic matter, and combined nitrogen, soluble phosphate, insoluble phosphate (deduced phosphate), sand, calcium sulphate, iron oxide, &c., present, and report thereon, keeping a record of all processes, which is examined. Guanos, bones, and other manures are given in the same way. Also kainit, ammonium sulphate, sodium nitrate, shoddy, blood, manures, &c., are given and required to be analyzed and reported by the student. For this work he is adjudged a certain number of marks which count towards his passing his class.

Seventh term.—This term is devoted to special preparation for passing the diploma examinations in qualitative and quantitative analysis. At the end of the term an examination is given in qualitative analysis, lasting one whole day. A mixture of substances is given containing about five metals and five acid radicals; this to be analyzed and reported on and notes of all experiments and their results to be shown up. No notes or book allowed to be taken in to the examination.

Also an examination in quantitative analysis, lasting over three weeks. In this two or three substances (which have been previously examined by the professor) are given to each student, that is, a soil in which to determine the water, organic matter, sand and silicates, oxide of iron

and aluminum, lime, potash, and nitrogen. A superphosphate in which to determine the ingredients above mentioned, and an oil-cake or other feeding stuff in which to determine water, oil, nitrogenous matter, fiber, mucilage, &c., ash, and to examine for starch and sugar and report generally upon its purity, condition, and suitability for feeding purposes.

The student before taking his diploma also has to satisfy the professor in a written examination (three hours) in agricultural chemistry and in a searching *viva voce* examination, during which he is examined in specimens of rocks, minerals, manures, seeds, feeding material, and the like.

Except during his examinations, the student has free access to the advice and help of the professor and his assistants in all practical and theoretical matters, and the particular processes most suitable to any particular analysis are pointed out and explained. During all the terms the student is required to keep a "labroatory journal," which is periodically examined, in which he enters a record of all experiments made, including the results observed or obtained, and the inferences or deductions drawn. A certain number of marks is allotted to these journals.

THE COLLEGE AS AN EXPERIMENTAL STATION.

I have referred to certain experiments made upon the College Farm in cattle feeding, in analysis of the soy bean and other foods, in the different races of sheep, and in the breeding of Cotswolds and Berkshires. In the character of the results of the last two experiments the Royal Agricultural College at Cirencester may fairly challenge comparison with any similar institution in the world.

As to the general plan of experimentation, the college publishes the following account:

GENERAL PLAN OF EXPERIMENTATION.

Series of experiments are carried on by the professors as a part of the college work, in which the senior students participate, and their practical utility is increased by the co-operation of various leading farmers in the neighborhood and of the Cirencester Chamber of Agriculture. Additional researches are prosecuted from time to time, as opportunity arises, in conjunction with other agriculturists and men of science at home and abroad. It is intended that these experiments and researches should deal with different varieties of cereals, grasses, roots, &c., the comparative merits of artificial fertilizers, occurrence and prevention of diseases, the feeding of growing, fattening, and work animals, &c., and thus at once enhance the value of the teaching given at college and contribute to the advancement and success of British agriculture.

AGRICULTURE: PROFESSOR WALLACE.

Examination for diploma.

1. What considerations are necessary in draining a stiff clay loam? Calculate the cost per acre, using 3-inch pipes, in the parallel drains.

2. What increase of flesh would you expect per week in an average fattening (1) bullock, (2) teg, and (3) pig, all well fed? What would be the proportions of dead weight to live weight when fat?

3. Describe the management of hill sheep for a year.

4. Describe the management of a flock of Cotswold ewes for a year.

5. Given 100 acres of good old pasture land, worth 40 shillings per acre of rent, how many bullocks would graze on it during summer? State how much and what kinds of food the same would require to make them fat during the following winter.

6. How should a milch-cow be fed and managed (*a*) before calving and (*b*) after calving, and why?

7. Describe milk and its products, giving their properties. What is a good average yield of each from a cow?

8. Describe the method of storing mangel adopted on the College Farm.

Agriculture: Arable, sheep, buildings, machinery, &c.

1. Describe the best rotations of cropping for light, medium, and heavy soils in this country, having regard for situation.

2. Particularize the acts of husbandry, and state the cost of cultivation in conducting each of the rotations described.

3. Given a 400-acre arable farm of sandy loam soil, Lady-day entry, and agreement precluding the sale of hay, straw, and roots, state the numbers and description of stock required for its proper occupation, their value, and the total amount of capital required to work the holding, explaining in detail for what it is wanted.

4. Describe the buildings best adapted for the profitable occupation of the above-named farm, cost, as adding to the rental value, to be taken into consideration.

5. Describe the buildings best suited to a 400 acre clay arable farm in the midlands occupied on the same terms as the above.

6. Compare the cost of horse and steam labor in preparing a good seed-bed on 100 acres of clean stubble upon a strong loamy soil; also upon the same quantity of a clean, light sandy stubble.

7. Describe the management and give the cost of keeping a flock of 200 ewes in the first-mentioned farm from Michaelmas to Michaelmas

8. Explain the management of the lambs from the above flock, giving cost of keep from weaning time till they are sold, assuming one-half to be ewe lambs, one-fourth to be rams, and one-fourth wethers.

9. Give a short history and explain the respective attributes of the undermentioned breeds of sheep: Southdowns, Shropshires, Herdwicks, Cheviots, Leicesters, Lincolns, and Cotswolds.

10. Name the implements required for a mixed arable and grass farm, and describe the different parts of Fowler's double engine system of steam cultivation with their action; also of an improved thrashing machine and a pair horse plow.

PRACTICAL AGRICULTURE: PROFESSOR LITTLE.

1. What are the best conditions of land for sowing (1) wheat, (2) barley, (3) clover, and (4) turnips, taking into consideration mechanical condition of the soil and cropping?

2. Give a list of special manures in most common use, and state their suitability for raising crops, and quantities applied.

3. In feeding two and one-half year old Short-horn cattle in stalls, give quantities of various foods you would use to make beef of them as quickly as possible.

4. Put marks against the following breeds of cattle to indicate their value (1) as beef producers and (2) milk producers; ten marks to be the maximum value in each case: (1) Short-horn, (2) Hereford, (3) Devon, (4) Ayrshire, (5) Galloway, (6) Angus, (7) Jersey.

5. Describe the principal differences in the systems of labor management in Northumberland, Westmoreland, and Lincolnshire.

6. What are the advantages of paying shepherds "in kind" as practiced in Northumberland?

7. Given a crop of swedes of 15 tons per acre, how many Cotswold tegs should such crop keep for fifteen weeks; and what increase of mutton should such sheep make per head in that period?

8. Give fair prices of piece-work on the College Farm for (1) hoeing peas and beans, (2) hoeing, setting out, and singling turnips, and (3) for filling dung.

9. What should be the cost of cutting, tying, stacking, and thatching fair crops of wheat and other grain, machines and horses being found?

10. Give the commonest Cotswold rotations. State any variations frequently adopted.

Practical agriculture: Cattle, dairying, grass land, pigs, &c.

CATTLE.

1. What breeds are best suited for producing (*a*) beef, (*b*) milk, (*c*) butter?

2. Suppose you wish to establish a dairy, what general principles would guide you as to choice of breed, age, number of years to be retained in the dairy, and ultimate disposal of cattle?

3. If you desired a herd for producing beef at a profit how would you begin and how proceed as to choice of breed, rearing, management after twelve months old, and time of maturity?

DAIRYING.

4. Mention points of importance in dairy management under following heads: Times and intervals of milking; times and intervals of

feeding; times and intervals of exercise; care of milk; churning of cream; ripening of Gloucester cheese.

5. In deciding the method of management of a farm for cattle carrying, what conditions would influence your decision as to the probable advantages of producing (*a*) beef, (*b*) milk, (*c*) butter, (*d*) cheese?

6. Describe the process of cheese-making and chief difference in making Cheddar cheese, Gloucester, and Stilton.

GRASS LAND, ETC.

7. Given a farm of 300 acres of medium soil, devoted chiefly to cattle, what crops should be grown, and about how many acres of each?

8. What would be a fair average crop of (*a*) hay, (*b*) mangels, (*c*) swedes, (*d*) common turnips, (*e*) drumhead cabbage? When should the crops be sown, when harvested, and in what rotation consumed? Give any special reason for the early or late consumption of any roots.

9. My neighbor has grown on clay land 8 acres of wheat at a cost of about £40; he has recently sold the grain for £18 10*s.*; the straw will about pay for the harvesting and marketing. If you were so unfortunate as to have such a field on your farm and could not get out of it, how would you manage it for the next three years?

PIGS.

10. Give the special points of merit and general characteristics of (*a*) large white breed, (*b*) Berkshires, (*c*) Tamworths.

AGRICULTURAL CHEMISTRY: PROFESSOR KINCH.

Diploma examination.

1. Give a concise account of the agencies, physical, chemical, and organized, concerned in the formation of soil from rocks.

2. To what constituents of soils is their absorptive power for bases generally due, and how would you proceed to estimate this power in any particular case?

3. How does the growth of trees assist in the formation and amelioration of soils, and in what respects do deciduous trees differ from conifers in their action?

4. Enumerate the principal sources of potash used for manure, and state how you would estimate potash in a manure.

5. What products of gas works are useful to the farmer? Give their composition and state with what precautions they should be used.

6. What are the most favorable conditions for the process of nitrification? Suggest means to prevent a large waste of nitrate in drainage water. Also do you know of any other chemical changes affecting the farmer which are brought about through the agency of minute organisms similar to those causing nitrification?

7. Compare the composition and the feeding and manurial values of

decorticated cotton cake, linseed cake, decorticated earth-nut cake, carob beans, maize, linseed, and rice.

8. Give a short account of the chemical life history of an oat plant.

9. What is meant by the albuminoid ratio of a food; how is it calculated? Give an example from one of the foods mentioned in question

10. How would a knowledge of this ratio guide you in the selection of foods for various animals?

BOOK-KEEPING: PROFESSOR THOMPSON.

Diploma examination.

Journalize, post in the ledger, and write a balance-sheet for the following statement; by means of a private ledger apportion the profits to the three partners and write a balance-sheet showing the amount of capital at the end of the year belonging to each:

A, B, and C start in business, their shares of capital being as 3, 4, and 5. A manages and receives £400 as salary, 5 per cent. interest to be charged on capital and on the drawings of the partners, and the profits are then to be equally divided between A, B, and C.

They commence with £4,800 in cash. From the outgoing tenant they buy stock, £3,050, and horses, £260; for tenant right they give £300 and pay in cash £3,000, giving a bill for the remainder.

During the year they buy stock from Smith, £300, sell stock for cash, £1,890. They consign stock to Scott valued at £800, he pays expenses, £26, sells it for £870; he remits a bill for £400 and for the remainder a check which is cashed; the bill is dishonored when it falls due; he ultimately fails and gives 5 shillings in the pound.

Rent, £700, is paid the landlord, and A's salary, £400, and wages, £340, are paid; A draws out £200, B £500, and C £600; interest is charged on these amounts. The tenant right depreciates one-third, horses depreciate 10 per cent.; Smith receives £280, £20 being discount. Bills payable are cashed less £10 discount; valuation of stock £5,627, and interest on capital is charged at 5 per cent.

ZOOLOGY: PROFESSOR HARKER.

Diploma examination.

1. Describe the morphology of a typical worm; distinguish the sub-kingdom *Vermes* from the *Arthropoda*.

2. What are the four principal groups of the parasitic worms? Give briefly characters sufficient to distinguish one from the other.

3. What is a weevil? Give a list of the noxious weevils you are acquainted with and say what plants they damage.

4. Describe the *wheat-midge*, give its history, and describe its various appearances in the field.

5. What are the Œstridæ or bots? What animals do they infest, and how?

6. What is the difference between the common field-mouse and the shrew-mouse, and of what importance is this?

PHYSICS: PROFESSOR OHM.

Diploma examination.

1. Describe the specific gravity bottle; in using this what preliminary precautions would you take, and show how you would proceed to determine the specific gravity of an insoluble powder?

2. In looking over an estate, what conditions would encourage you to fix a hydraulic ram? To what extent has this proved a valuable machine?

3. Write out the laws of capillary attraction, and show how these laws may be demonstrated.

4. Compare the three forms of wheels commonly in use. What necessary arrangements would you make before fixing each of these wheels, and why?

5. Write out the laws of evaporation and ebullition. What do you understand by the term *latent heat*? Mention experiments which prove that a large amount of heat is rendered latent during the process of evaporation.

AGRICULTURE: PROFESSOR WALLACE.

Class 1 A.

1. Give a good classification of soils.

2. Describe the actions of glaciers in forming soils. Where do we find soils formed from glacier deposits in this country?

3. How are alluvial soils formed? Where are they found in this country? Describe their characters.

4. Show by diagram sections of different kinds of drains (with and without pipes), and state in what soils each may be used.

5. Describe the process of irrigation, and state its advantages.

6. Why is lime applied to soils? Mention the different forms in which it may be applied and the characters of each.

7. Describe the operation of "paring and burning," and state its advantages and disadvantages.

8. How can farm-yard manure be best preserved (1) at the homestead and (2) in the field?

Class 1 B.

1. What are the advantages and disadvantages of "water" and "wind" power as compared with "steam" power?

2. Describe (shortly) a double furrow plow, and state its advantages as compared with the ordinary swing plow.

3. Explain the construction of (1) a Cambridge roller and (2) a cross-hill roller; for what purposes are they used?

4. What is the usual difference between a "grass mower" and a "reaping machine"? Why should it be so?

5. Name and describe briefly the different systems of steam cultivation.

6. Give the construction of the zigzag harrow. Explain why it is so constructed. What are its uses?

7. What is the weight of the standard bushel of (1) wheat and (2) oats in the market of this district? How is barley sold?

8. (*a*) Show how the gradual increase of wages tends to raise the standard of work in this country. (*b*) Describe the Bothy system of lodging young plowmen in Scotland.

Class 2 A.

1. State in bushels what would be an average crop of wheat, barley, and oats. What proportion of straw would you expect to grain. And arrange the straw in order of feeding quality.

2. Describe (shortly) the advantages and disadvantages of three ways of sowing grain. Calculate the cost of drilling wheat per acre.

3. Calculate the cost per acre of cutting grain (*a*) by scythe and (*b*) by reaper. Show how you make your estimates.

4. At what seasons and how deep are beans and peas sown? How much seed is used per acre?

5. Name the different varieties of turnips and swedes grown on the College Farm. Give the order and time of sowing and consuming and the manure applied.

Class 2 B.

1. Give lists of "seeds" (grasses and clovers) suited to sow on land to lie out (1) one year, (2) two years, and (3) for permanent pasture. Why do you arrange the mixtures so?

2. What actions have the following manures when applied to permanent pastures: (1) Nitrogenuos manures alone; (2) mineral manures alone; (3.) Nos. 1 and 2 mixed?

3. Describe (shortly) the different ways of storing roots.

4. Calculate the cost per acre of ridging land for a green crop, putting 16 tons farm-yard manure per acre into the ridges from a heap in the field; horse, 3*s*., men, 2*s*. 6*d*. per day.

5. Explain how a simple experiment may be carried out in a turnip field to test which of the three valuable manurial substances, nitrogen, potash, and phosphoric acid, was most wanted.

Class 3.

1. Describe the feeding and treatment of a cow giving milk from the day she calves in March for one year.

2. Which green crops and pasture plants are unsuited to cows in milk, and why?

3. What are the causes of inflammation of the udder in cows, and how is it prevented?

4. Describe the treatment of curd in the Cheddar system of cheese-making after all the whey that will run off is removed.

5. What are the principal differences between ordinary milk and colostrum, or the first milk after calving? Why is the latter well suited to young calves?

6. What takes place when milk sours? What causes souring, and how is it prevented?

FARM JOURNAL: PROFESSOR WALLACE.

Classes 1 *A and* 1 *B.*

Describe the breeding and management of the pigs on the College Farm.

2. What is the benefit derived from keeping a farm journal? Describe the method of keeping it at the College. Suggest improvements on the same.

3. What number of bushels of wheat, barley, and oats can be thrashed per day of ten hours at the College Farm? Explain why the amount should differ.

CULTIVATION BOOK: PROFESSOR WALLACE.

Classes 2 *and* 3.

1. Give the cultivation for wheat of No. 1, No. 5, and No. 10 fields, and give reasons why those differed.

2. What are the costs per acre on the College Farm of (1) hoeing wheat and barley; (2) hoeing swedes and turnips a first and second time; (3) hoeing mangels three times?

3. How are potatoes and mangels covered in pits? Explain why and give costs.

4. Give (shortly) the cultivation of a potato crop.

AGRICULTURAL LAW: PROFESSOR FAWCETT.

1. State (shortly) the modes of making a binding bargain, to be carried out within a year, for the sale of an animal or goods (1) under the value of £10 and (2) over that value.

2. What tests should you apply to ascertain whether a statement made by the seller of a horse is a warranty or a mere representation?

3. State the general principles by which you would decide what is unsoundness in a horse, so as to constitute a breach of warranty of soundness.

4. To what extent is the "rule of the road" binding on a driver?

5. Your dog bites a man and afterwards worries a sheep. What will have to be proven in each case in order to enable the bitten man or the owner of the bitten sheep to recover damages against you?

INORGANIC CHEMISTRY: PROFESSOR KINCH.

Class 1 *A.*

1. State the laws of chemical combination, giving examples.

2. Define the terms acid, anhydride, normal salt, acid salt, basic salt, efflorescence, deliquescence, deflagration.

3. What gases are contained in atmospheric air? Give the proportions of those which are most important, and state reasons for believing that air is a mechanical mixture and not a compound.

4. Classify natural waters. State the usual impurities present in them and how they may be detected.

5. Describe the preparation and properties of ammonia.

6. Give the formulæ of ozone, hydrogen, peroxide, red mercuric oxide, chloric acid, nitric acid, and laughing-gas.

7. Give an account of the laboratory lesson on the preparation of oxygen.

Class 1 *B.*

1. Give an account of the chief characteristics of sulphur, its behavior on heating, and its uses in the arts and in agriculture.

2. Describe the process for the production of superphosphate of lime, giving an equation.

3. You are given ordinary sodium phosphate, microcosmic salt, acetic acid, white of egg, and silver nitrate; how would you illustrate characteristic reactions of the three phosphoric acids?

4. What is meant by the hardness of water; to what is it due? Name some of its effects and how it may be remedied.

ORGANIC AND ANALYTICAL CHEMISTRY: PROFESSOR KINCH.

Class 2 *A.*

1. How did Wöhler obtain urea artificially, and how did its production in this way affect the views held with regard to organic chemistry?

2. Describe the preparation of chloroform, and state its properties and uses.

3. Having at your disposal ethylene, sulphuric acid, and water, how would you prepare common alcohol and ether?

4. Give the name and formula of a number of each of the following families of organic compounds: Saturated hydrocarbons, alcohols, ethers, mercaptans, anhydrides, acids, and organo-metallic bodies.

5. How is oxalic acid prepared from saw-dust?

6. An organic body containing only carbon, hydrogen, and oxygen gave, on combustion, the following percentages: C., 71.43; H., 9.53; O., 19.04; its vapor density, compared to hydrogen, was found to be 41.7; required, its molecular formula.

7. How would you detect copper, arsenic, iron, and magnesium occurring together in solution?

Class 2 B.

1. Classify the more important carbohydrates. Give a list of the principal plants from which sugar is extracted, stating from what part of the plant it is obtained.
2. You are given cotton, sulphuric acid, nitric acid, lime, and water; how would you prepare glucose and gun-cotton?
3. Name some organic bases existing in the animal body.
4. State the chemical composition of bone and of blood.

AGRICULTURAL CHEMISTRY: PROFESSOR KINCH.

Classes 3 A and B.

1. State the average composition of good farm-yard manure as far as its most valuable constituents are concerned; what conditions are most conducive to prevention of loss in keeping; and why are the effects of farm-yard manure usually more striking on light than on heavy soils?
2. Give an account of some of the effects of cropping on the subsequent condition of soils, and show how and why different crops differ in their effects.

GEOLOGY: PROFESSOR HARKER.

Classes 1 A, 2 A, and 3 A.

1. Describe the origin of a glacier and its action on descending a valley. Distinguish between a *glacier* and a *continental ice-sheet.*
2. Define the following terms: Loam, marl, chert, porphyry, amygdaloid, shale, and trap.
3. What are the evidences of successive upheaval and depression of land areas?

BOTANY: PROFESSOR HARKER.

1. Contrast *Protococcus* and *Saccharomyces.*
2. Give life history of potato fungus.
3. What is ergot of rye?
4. What is *dry rot?*
5. How does a plant obtain its food from the soil?

Similar questions are proposed in the different departments of physics and meteorology, and in surveying, engineering, book-keeping, veterinary science, and drawing.